The mineral industries of Canada.

By *H. Mortimer-Lamb*, Secretary, Canadian Mining Institute. Montreal, Canada.

(With 2 plates).

INTRODUCTION.

The purpose of this paper is to direct attention to recent progress of the mining industries; to indicate the mineral potentialities of the Dominion; and, in general, to present a survey of conditions in the hope that such information may conduce to a more comprehensive study of a mineral area of not only extraordinary extent, but possessing numerous unique features and characteristics.

HISTORICAL OUTLINE.

The first recorded discovery of mineral in Canada was that made by the expedition to Hudson Bay under Sir Martin Frobisher in the year 1576. After the expedition had returned to England, a piece of rock taken from Hall's Island in Frobisher's Bay proved to be rich in gold, and in consequence a second and subsequently a third voyage was undertaken to prospect the new field; these expeditions, however, were without commensurate result. In the early eighteenth century ron ore was mined and smelted in the Province of Quebec; while copper mining was first undertaken in the year 1770. Coal was discovered in Nova Scotia in 1672, and a first attempt at systematic mining was inaugurated in 1720. Again, later, in 1835, a discovery of coal was made at Fort Rupert on the Pacific Coast; and this was followed in 1858 by the notable discoveries of placer gold in the Fraser River deposits, and in the Cariboo area of British Columbia.

These references, however, while no doubt of interest to the chronologist, only very indirectly bear on the present status of the industry whose inception as such may be said to date from the completion of the construction of the Canadian Pacific Railway across the Continent in 1885. By means of this great achievement, a vast territory was at once rendered accessible for exploration, while at the same time the establishment of mineral industries became commercially possible by the creation of favourable contributory conditions in respect of transport and markets.

But perhaps the most notable instance of mining development immediately consequent upon the construction of the Canadian Pacific Railway, was the opening up of the great Sudbury nickel areas in the Algoma district of the Province of Ontario, the production from which field between that date and the present represents a value of over a hundred million dollars. Here the railway was directly responsible not only for the subsequent development, but for the actual initiation of industry, for to the discovery of one of the larger occurrences in the course of the construction of the main line near Sudbury may be traced all later activity.

For a period of nearly five years after the completion of the Canadian Pacific, however, progress was slow; but about the year 1890 a very distinct improvement in conditions is observable, and since then the growth and expansion of the industry has been extraordinarily gratifying. Thus, in 1890, the asbestos industry in the Province of Quebec suddenly sprang into great prominence, becoming importantly productive; in Nova Scotia, in the same year, iron and steel works were established at Sydney; corundum was first mined in Ontario; the famous Rossland gold-copper deposits in British Columbia were discovered; and, in general, the value of the mineral production of the Dominion showed a momentous increase. This, then, was the beginning of the considerable expansion that has since taken place. Between the years 1890 and 1895 new discoveries and new developments followed one another in rapid succession. This was especially marked in Western Canada, where within this short period of time the rich silver-lead deposits of the Slocan district in West Kootenay division, and of Fort Steele in the East Kootenay division were discovered and worked; the development of the unique copper area of the Boundary district was commenced, and the establishment of smelters at Trail and at Nelson, inaugurated metallurgical enterprise in British Columbia. New territory was constantly added to the area of productivity, with the result that at the close of 1897, the value of the mineral output for that year showed an increase of nearly 260 per cent over the returns of 1887.

The commencement of active mining development and operations in the coal fields of Alberta in 1897 represented another important mile-stone in the march of progress; while the discovery of the Yukon gold placers at about the same period stimulated interest in the mineral resources of the country to a remarkable degree.

The third decade in the history of the mining industries of the country has been no less eventful than the second; while, as is natural, the rate of progress has been correspondingly greater. Industry is no longer on a tentative footing, but is now regularly organized and firmly established. Individual effort has generally given place to corporate control, while the tendency of late in most industries has been in the direction of the consolidation of interests with a view to the attainment of a maximum efficiency and economy of operation. Thus, from an insignificant position Canada has, within this period of time, been brought to occupy a high rank among the mineral producing countries of the world, and is now the chief source of the world's supply of asbestos and nickel; while only less relatively important is her present production of silver, copper, gold, coal and chromite; and this notwithstanding that certainly not over a third of the country has yet been even nominally explored or prospected.

Point is given to this statement by the fact, emphasised by Mr. R. W. Brock, the Director of the Geological Survey of Canada, in his introduction to a recently issued report[1] on the Geology and Economic Minerals of Canada, that while six years ago the line representing prospected territory would probably have been placed considerably north of Lake Temiskaming, Ontario, yet only a few miles west of a silver-lead deposit on Lake Temiskaming — a deposit the existence of which had been known for a century and a half — lay the silver veins of Cobalt, the occurrence of which were not suspected until the autumn of 1903, when the phenomenal richness of the area was revealed as a result of railway construction through the district. Cobalt, it may be further mentioned, is situated only an hundred miles north of North Bay on the main line of the Canadian Pacific Railway, and for many years, therefore, has been readily accessible to prospectors. The discovery of the Cobalt district has been perhaps the most important event in the history of the mining industry in recent years. Apart from the fact the production of silver from the area already represents the considerable total value of $ 32,500,000, the unique character of the deposits and the remarkable values contained in the ores has created widespread interest and attention, and has, no doubt, influenced and stimulated to an important degree exploration effort and recent industrial expansion generally throughout Central Canada.

To conclude, in brief, this necessarily hasty historical survey: The last ten years has witnessed an unprecedented development in all branches of mining endeavour. From small beginnings the iron and steel industries of Nova Scotia and Ontario have now become of considerable importance, there being at present in operation in the latter Province seven well equipped modern smelting plants, in most cases employing secondary metallurgical processes. The progress of coal mining has been even more remarkable, chiefly in consequence of the development of the Alberta and British Columbia fields, where over a hundred collieries are at present producing coal. The asbestos industry in the Province of Quebec has been established on a firm footing, and its annual production now represents between 75 and 80 per cent of the World's consumption. The nickel industry of Ontario, employing nearly four thousand men and contributing 70 per cent of the world's requirements, has been brought to occupy a position of pre-eminent importance. As a result of operations in the Cobalt district, which is the richest individual silver-producing area in the world, Canada now ranks third among the silver-producing countries of the world in point of value of anual output.

In copper mining, achievements in British Columbia have been especially noteworthy, and as a result of naturally favourable conditions, together with the perfection of mining and metallurgical practice, low grade copper ores carrying less than 1—$^1/_2$ per cent. copper and small gold and silver values and yielding under five dollars per ton, are being and for some years past have been profitably won. In fact, in no other direction is progress more apparent than in the development of the metallurgical industries of Western Canada, as indicated by the reduction in costs in the treatment of copper ores, representing a difference of 100 per cent. in ten years; while it is claimed that a certain class of ore is now smelted and converted into blister copper at a cost of approximately a dollar per ton. Considering the relatively high cost of labour, such an achievement is without parallel.

In the northern placer fields of the Yukon, notable changes have taken place. The day of the individual miner, employing crude methods and appliances, has passed away; and instead, the

[1] »A Descriptive Sketch of the Geology, and Economic Minerals of Canada«, by G. A. Young. Page 8: Canadian Geological Survey, Ottawa, 1909.

557.1
M84m

field is being exploited by great corporations, who have established dredges on the rivers, built miles of flumes and ditches, and in other directions invested enormous sums in equipment and plant in order to operate on a scale heretofore unheard of.

At the close then of the period under review, the industry is found to have emerged from a condition of incipiency and incertitude to one of maturity and stability, well ordered and well organized. Initial difficulties and disabilities have to a large degree been surmounted or have disappeared. Costs have been very materially reduced by the improvement of methods, the cheapening of transport, and the electrification and utilization of water powers; while the steady increase of population warrants the belief that the time is not far distant when the demands of a home market will justify the establishment of refineries and manufactories in the country itself. A beginning in this direction has already been made.

STATISTICAL REVIEW.

In substantiation of the above general statements a few figures from official sources may now be presented. The annual mineral production since 1886 is shown in the following table:[1]

	$		$
1886	10,221,255	1898	38,412,431
1887	10,321,331	1899	49,234,005
1888	12,518,894	1900	64,420,983
1889	14,013,113	1901	65,804,611
1890	16,763,353	1902	63,211,634
1891	18,976,616	1903	61,740,513
1892	16,623,415	1904	60,073,897
1893	20,035,082	1905	69,525,170
1894	19,931,158	1906	79,057,308
1895	20,505,917	1907	86,865,202
1896	22,474,256	1908	85,927,802
1897	28,485,023	1909	90,415,763

This table very strikingly illustrates the three marked divisions of industrial development to which illusion has already been made. It will be noted, for example, that growth was gradual until 1890, when a sudden advance is shown; that for another period of six or seven years no great amelioration was apparently in progress, but that towards the close of the second decade, about the years 1898—1900, a remarkable improvement as indicated by the increases, took place; and again this is shown in the statistics covering the third decadal period. It is also interesting to note that while in 1886 Canada's mineral production represents only $ 2.23 per capita; in 1909, it represented about $ 12.00 per capita; while the actual increase was nearly ninefold. The total value of the minerals produced during the twenty-four years of the industry's history is $ 1,116,932,342.00, of which nearly one-third is ascribable to gold output.

The progress and growth of some of the more important individual industries are shown in the following tables:

ASBESTOS.

year	*tons (2000 lbs.)*	*value* $
1880	380	24,700
1885	2,440	142,441
1890	9,860	1,260,240
1900	21,621	729,886
1905	50,669	1,486,359
1907	60,761	2,036,428
1908	66,548	2,555,361
[2] 1909	88,315	2,315,816

It will be noted that the value of the output in 1890 is apparently disproportionate to the tonnage produced in that year. This seeming discrepancy is, however, explained by two facts: First, the ruling prices during the years 1889, 1890 and 1891 were extraordinarily high; and, secondly, production was confined almost entirely to crude fibre of the highest grade. Milling methods, whereby the lower grade material were profitably utilized, were not employed until the years 1897—98. With this explanation it will be observed that the progress of the industry has been steady and persistent.

[1] Report, Division of Mineral Resources and Statistics, Department of Mines, Ottawa.
[2] Asbestos & Asbestic. Estimate Bureau of Mines, Quebec, Que.

CHROMITE.

year	*tons*	*value*
		$
1886	60	945
1894	1,000	20,000
1900	2,335	27,000
1908	7,225	82,008
1909 (estimated)	5,000	83,740

The mining of chromite iron ores, the occurrence of which is confined, so far as at present known, to localities in the Eastern Townships of the Province of Quebec, was not actually initiated until 1894. Operations are being at present actively prosecuted by a Canadian company at Black Lake. A limited quantity of the ore is utilized locally in the manufacture of ferro-chrome, but the bulk of the product is marketed in the United States.

COAL.

year	*tons (2,240 lbs)*	*value*
		$
1886	2,116,653	3,739,840
1890	3,084,682	5,676,247
1900	5,777,319	13,742,178
1905	8,667,984	17,520,263
1908	10,886,311	25,194,573
1909 (estimated)	10,411,955	24,431,351

Prior to 1886 practically all the coal produced in Canada was mined in the Provinces of Nova Scotia and New Brunswick. In 1890 the production from the Western coal areas represented 29 per cent., of which 25 per cent. was contributed by British Columbian collieries. In 1900, as a result of the development of the Crow's Nest field, the British Columbia production represented 31 per cent of the total Canadian output. The improvement of conditions in Nova Scotia, in part attributable to the promotion of large consolidations and a concentration of effort, was responsible for again reducing for a period the Western percentage, notwithstanding the steady advance of the coal mining industry in British Columbia; but in 1905 production from the new coal fields of Alberta having considerably increased, Western coal production is shown as being 34.5 per cent. of the aggregate Canadian output. Since then, the West has continued to contribute a proportionately greater output, and in 1909 the distribution was Nova Scotia, 54.5 per cent.; Saskatchewan and Alberta, 20.5 per cent.; and British Columbia, 24.3 per cent.

The following table shows the growth of the industry by Provinces:

Nova Scotia.

year	*tons*	*value*
		$
1872	880,950	1,568,446
1880	1,032,710	2,000,079
1885	1,352,205	2,418,735
1890	1,984,001	3,407,864
1900	3,298,791	6,496,982
1908	6,652,539	13,364,476
[1]1909	5,683,750	11,418,249

Alberta and Saskatchewan.

year	*tons (2,240 lbs.)*	*value*
		$
1887	74,152	157,577
1890	128,953	193,498
1895	185,654	414,064
1900	357,950	839,375
1905	1,046,513	2,167,249
1908	1,836,217	4,381,101
1909	2,142,172	4,983,343

[1] A protracted strike was responsible for a falling off in output.

British Columbia.

year	*tons (2,240 lbs.)*	*value*
		$
1880	267,595	817,086
1885	365,596	999,072
1890	678,140	2,056,035
1895	939,654	2,834,049
1900	1,590,178	4,799,553
1905	1,736,696	5,211,030
1908	2,333'708	7,292,838
1909	2,538,004	7,931,263

COKE.

year	*tons*	*value*
		$
1886	11,564	41,391
1890	36,564	133,344
1895	53,356	143,047
1900	157,134	649,140
1905	700,488	2,436,211
1909	875,080	3,557,147

These returns very clearly indicate the growth of Canadian metallurgical enterprise. Prior to 1893 the manufacture of coke was confined to the Province of Nova Scotia, and the production, as will be noted, was inconsiderable. The establishment, however, of iron and steel works at Sydney in 1900, and the inauguration of smelting in 1896 in British Columbia, naturally stimulated a demand for the product; and at the close of the year 1909 there were 670 ovens in operation in Nova Scotia; 226 in Alberta, and 767 in British Columbia.

COPPER.

year	*lbs.*	*value*
		$
1886	3,505,000	385,550
1890	6,013,671	947,153
1895	7,771,639	836,228
1900	18,937,138	3,065,922
1905	48,092,753	7,497,660
1909	54,061,106	7,018,213

Copper mining has been carried on since the year 1865 in both provinces of Ontario and Quebec; but the output was relatively small until 1886 when the nickel-copper deposits of Sudbury, Ontario, were first worked for their copper contents. The great increase in annual production dates, however, from 1895, when the British Columbia copper mines in the Rossland district and rather later in the Boundary and Coast districts first became importantly productive. By 1900 the mines of the Boundary district, British Columbia, that are at present the chief source of Canadian copper output, were being operated on a large scale.

By Provinces the production has been as follows:

Quebec.

year	*lbs.*	*value*
		$
1886	3,340,000	367,400
1900	2,220,000	359,418
[1]1909 (estimate copper ore)	35,000 tons	159,588

Ontario.

year	*lbs.*	*value*
		$
1886	165,000	18,150
1890	1,303,065	205,233
1895	4,576,337	492,414

[1] Return Bureau of Mines, Quebec, Preliminary Report.

Ontario. Continued.

year	*lbs.*	*value* $
1900	6,740,058	1,901,215
1905	8,779,259	1,368,686
1909 (estimate)	15,746,699	2,047,071

British Columbia.

year	*lbs.*	*value* $
1894	324,680	31,039
1900	9,977,080	1,615,289
1905	37,692,251	5,876,222
1909 (estimate)	37,314,407	4,850,873

CORUNDUM.

year	*tons (grain corundum)*	*value* $
1900	3	300
1908	1,089	100,398
1909	1,491	157,398

Canada is practically the only country from which pure corundum is obtained. The marketed product is valued at $ 96.62 per ton.

GOLD.

year	*ounces (fine)*	*value* $
1887	57,465	1,187,804
1895	100,806	2,083,674
1897	291,582	6,027,016
1900	1,350,176	27,908,153
1905	685,012	14,159,195
1908	476,112	9,842,105
1909 (approximate)	460,000	9,790,000

The present chief sources of the gold won in Canada are the lode mines and placers of British Columbia, and the placers of the Yukon Territory. In 1887 the major proportion of the production was derived from the British Columbia placers, while the remainder represented the Nova Scotia yield from lode mining. In 1895, output was augmented by the returns from the Rossland (B. C.), gold-copper mines, production from which then commenced, while in this year a first considerable yield is recorded as having been made in the Yukon Territory. 1900, however, marked the height of the Yukon's productivity and thenceforward as the richer areas became exhausted the output gradually diminished until in 1908 it reached its lowest point. In 1909 a slight increase is again shown, and it is expected that in the future the territory will continue to yield handsome returns as a result of operations recently initiated on a large scale and under favourable auspices by great corporations. Meanwhile, the British Columbia gold-copper and copper-gold mines of the Rossland and Boundary districts, respectively, are the chief contributors to the Dominion's annual gold output. The distribution, however, during recent years is better shown in the following tables giving the Provincial and Territorial returns:

Nova Scotia.

year	*value* $
1887	413,631
1890	474,990
1900	598,553
1905	283,353
1908	244,799
1909 (estimated)	250,000

Ontario.

year	*value*
	$
1887	6,760
1895	62,320
1900	297,495
1905	91,000
1908	60,337

Yukon.

year	*value*
	$
1887	70,000
1895	850,000
1897	2,500,000
1898	10,000,000
1899	16,000,000
1900	22,275,000
1901	18,000,000
1902	14,500,000
1903	12,250,000
1904	10,500,000
1905	7,876,000
1908	3,600,000
1909	3,960,000

British Columbia.

year	*value*
	$
1887	693,709
1890	494,436
1895	1,266,954
1900	4,732,105
1905	5,902,402
1908	5,929,880

PIG IRON.

year	*tons*	*value*
		$
1887	24,827	366,192
1900	96,575	501,698
1905	525,306	6,475,186
1908	630,835	8,111,190
1909	757,162[1]	9,581,864

The mining of iron ore has as yet not assumed important proportions in Canada, the major part of the pig iron production being derived from imported ores. Thus, in 1909, 1,234,990 tons of ore were imported, mainly from Newfoundland, while but 231,994 tons of Canadian ores were utilized in blast furnaces. The table as given serves, however to illustrate the progress of the iron industry in Canada during the last ten years. For present purposes the position of the steel industry may be indicated by merely quoting the returns for, respectively, 1908 and 1909:

STEEL (Ingots and castings).

year	*tons*	*value*
		$
1908	588,763	10,916,602
1909	754,719	14,359,710

[1] Classified as: Bessemer, 222931 tons; Basic, 400021; foundry including miscellaneous, 116307 tons

There are at present in operation in Canada eight steel plants, exclusive of three electric furnace plants making ferro products.

LEAD.

year	*pounds*	*value*
		$
1887	204,800	9,216
1892	808,420	33,064
1895	16,461,794	531,716
1900	63,169,821	2,760,521
1905	56,864,915	2,676,632
1908	43,195,733	1,814,221
1909	45,857,424	1,959,488

It will be observed from the above table that lead production first became important in the year 1895. This date represents the establishment of the industry in British Columbia, the rich mines in the Kootenay division having been discovered some three or four years previously. Practically all the lead produced in Canada is derived from British Columbia ores. In 1900 a maximum output was attained in consequence of specially favourable market conditions. Since 1904, a large proportion of the output has been refined electrolytically in the country, and is manufactured for home consumption.

NICKEL.

year	*pounds*	*value*
		$
1889	830,477	498,286
1890	1,435,742	933,232
1895	3,888,525	1,360,984
1900	7,080,227	3,327,707
1905	18,876,315	7,550,526
1908	19,143,111	8,231,538
1909	26,282,991	9,461,877

The above figures demonstrate most eloquently the extraordinary expansion of this Canadian industry in recent years. The present output of nickel is derived almost entirely from the operation of two companies working mines in the Sudbury district in Ontario, although a certain proportion of the metal is contained in the silver-cobalt ores now mined in the Cobalt district. The Sudbury ores are smelted locally to a 74 to 82 per cent. copper-nickel Bessemer matte, which is subsequently refined in the United States and Great Britain. A recent innovation is the manufacture locally of an alloy, known as "monel" metal, containing, approximately, 30 per cent. copper and 70 per cent. nickel, having great tensile strength. It is also non-corrosive, and possesses other properties peculiarly valuable for engineering purposes. A considerable production has already been marketed.

SILVER.

year	*ounces*	*value*
		$
1887	355,083	347,271
1890	400,687	419,118
1895	1,578,275	1,030,299
1900	4,408,225	2,740,362
1905	5,989,667	3,614,883
1908	22,106,233	11,686,239
1909	27,878,590	14,358,310

It will be observed from the foregoing that there have been two notable periods of silver mining activity, the first commenced between the years 1890 and 1895 with the operation of the argentiferous lead ores of British Columbia, the yield from which until 1904 constituted over 90 per cent. of the total annual Canadian production; and a second period, opening about the year 1905 when the output from the Cobalt district in Ontario became important. The returns of silver production from the Provinces of British Columbia and Ontario, respectively, are corroborative of this statement:

British Columbia.[1]

year	*ounces*	*value*
		$
1887	17,690	17,331
1893	227,000	195,000
1895	1,496,522	977,229
1900	3,958,175	2,309,200
1905	3,439,417	1,971,818
1908	2,631,389	1,321,483

Ontario.[2]

year	*ounces*	*value*
		$
1887		349,330
1895	nil	nil
1900		96,367
1904	206,875	111,887
1905	2,473,452	1,372,577
1906	5,433,984	3,689,286
1907	10,028,259	6,551,608
1908	19,444,400	10,543,410
1909 (estimated)	25,737,037	12,382,659

MISCELLANEOUS MINERAL PRODUCTION.

A fair conception of the progress of other Canadian mining industries may be obtained from the following comparative statement of mineral production for the years 1887, 1900 and 1909.

	1887 *value* $	1900 *value* $	1909 *value* $
Antimony	10,860	nil	nil
Cobalt	nil	nil	66,319
Zinc	nil	4,810	250,000
Arsenic	nil	nil	64,000
Feldspar	nil	nil	157,398
Graphite	2,400	31,000	35,694
Grindstones	64,008	53,450	50,944
Gypsum	157,277	259,009	667,816
Magnesite	nil	nil	2,508
Mica	29,816	166,000	154,106
Ochres and Barytes	6,133	23,003	29,213
Mineral Waters	11,456	75,000	177,304
Natural Gas	nil	417,094	1,205,943
Petroleum	556,708	1,157,007	559,604
Phosphate	319,815	18,000	41,618
Pyrites	—	—	196,312
Quartz	—	—	63,032
Salt	166,394	279,458	415,219
Talc	800	6,365	12,172
Tripolite	—	1,950	—
Cement, Portland	—	562,916	5,266,008

[1] Annual Report Minister of Mines, British Columbia, 1908.
[2] Reports Ontario Bureau of Mines.

Clay Products.

	1887 *value* $	1900 *value* $	1909 *value* $
Brick	986,689	2,275,000	4,200,000
Sewer pipes, etc.	—	690,975	1,300,000
Lime	394,859	800,000	1,049,473
Sand & Gravel (exports)	—	101,666	256,166
Stone	142,506	80,000	340,047
Limestone for flux	—	—	—
marble, limestone, and sandstone	552,267	1,520,000	1,600,000

Other minerals produced in Canada, but so far on a small scale only, are mercury, palladium, platinum and osmiridium.

GEOLOGY AND PHYSIOGRAPHY.

The continental extent of the territory embraced by the Dominion of Canada will, perhaps, be more readily appreciated from the comparative viewpoint. Thus, the statement that the total estimated area of the country is 3,729,665 square miles becomes more cogent when it is added that this is a greater area than that of the United States, and very nearly as great as that of the whole of Europe. It is essentially a region of lakes and navigable rivers, providing unequalled facilities for cheap transport and the development of water powers. The river St. Lawrence constitutes a navigable route to the heart of the Continent of nearly 4,000 miles, and with its numerous tributaries drains a basin of approximately 530,000 square miles. The rivers emptying into Hudson Bay and Strait drain an estimated area of 1,486,000 square miles. In Western Canada, northwest of the Hudson Bay Basin, a region of about 1,290,000 square miles is mainly drained by the Mackenzie River and its tributaries. The Pacific Basin, having an area of about 387,300 square miles, drainage, is afforded by numerous rivers including the Fraser and the Columbia; while the Yukon River, 1,760 miles long, drains a region in the north of about 145,000 square miles.

The two important mountain systems of North America are the Appalachian in the East and the Cordilleran in the West. These converge to the South and between them lie the great central plain of the Continent.

Physiographically and geologically a natural Eastern and Western division of the country might be made. An Eastern division, a region of relatively low relief, underlain by Palaeozoic or older strata; and a Western division differentiated by the continuation of sedimentation through Mesozoic and Cenozoic times; and in the extreme West, by evidences of igneous activity and the operations of mountain building forces. For purposes, however, of convenience of description, the Geological Survey of Canada has employed a six-fold division[1] as follows:

(1) *The Appalachian Region,* including the portion of Canada East of a line running from Lake Champlain to the neighbourhood of the City of Quebec, and thence down the Channel of the St. Lawrence.

(2) *The St. Lawrence Lowlands,* including the plains bordering the St. Lawrence River above the City of Quebec, and extending through Southern Ontario to Lake Huron.

(3) *The Laurentian Plateau Region,* including the great U-shaped upland surrounding Hudson Bay.

(4) *The Arctic Archipelago,* including the islands of the Artic Ocean, north of Hudson Bay.

(5) *The Interior Continental Plain,* including the central belt of plains lying between the Western margin of the Laurentian Plateau and the Rocky Mountains.

(6) *The Cordilleran Region,* including the mountainous region of the Western portion of the Continent.

The Canadian Appalachian Region.

The Canadian Appalachian region is characterised geologically by a very complicated structure, the strata over large tracts having been greatly disturbed, traversed by faults, uplifted, and intruded by granitic and other igneous rocks. Physiographically, the region though essentially broken, and frequently rugged and hilly, includes many fertile valleys, while the country is generally well forested. Strata of Carboniferous and Permian age are confined almost wholly to the Maritime Provinces, and with the exception of the Triassic measures that occur along the shores of the Bay of Fundy, neither the Mesozoic nor the Tertiary is represented in the Canadian Appalachian region. The Crystalline rocks of pre-Cambrian age occupy considerable areas in

[1] »A Descriptive Sketch of the Geology, and Economic Minerals of Canada«, G. A. Young, page 29.

the Eastern Townships of Quebec, the Gaspe Peninsular, in New Brunswick and in the Northern and Eastern portions of Cape Breton Island; while Cambrian and Ordovician strata occupy much of south-eastern Quebec. Devonian strata are also widely distributed over the Canadian Appalachian region.

The economic minerals at present recovered and occuring in the Appalachian region are asbestos, coal, gold, copper, chromite, iron, barite and gypsum; while lead, tin, manganese, tungsten, antimony, oil and sulphate of ammonia are also known to occur.

St. Lawrence Lowlands.

In this region, which is underlain by somewhat disturbed Palaeozoic measures, conditions have not been favourable to the development of metallic minerals. It includes, however, valuable and important petroleum and salt resources, while throughout the region brick and tile manufacture constitute considerable industries. Gypsum occurs in the Salina formation of South-Western Ontario; while extensive peat bogs occur in various localities.

The Laurentian Plateau.

Except for a zone of Palaeozoic rocks bordering Hudson and James Bays on the South-Western and in the small marginal areas, this great U-shaped region is altogether underlain by rocks of pre-Cambrian age. The area of the region is estimated as being over 2,000,000 square miles, or more than half the total area of Canada. This statement is of extreme interest and importance in view of the known fact that formations belonging to this geological period are peculiarly favourable to the occurrence of mineral deposits of economic value. Thus, within the extension of this area across and adjoining the Canadian border in the States of Michigan, Wisconsin and Minnesota, occur the greatest iron ore deposits and some of the most noteworthy copper deposits in the world; while, in Canada, along the Southern fringe of the area, which alone has been at all prospected, lie the nickel mines of the Sudbury — the largest and most valuable deposits of nickel in the world — and the phenomenally rich silver deposits of the Cobalt District; the unique corundum deposits of Eastern Ontario and ores of gold, copper, lead, sulphur, and arsenic; while also important occurrences of graphite and mica are found.

The physical features of the area are characteristically uniform, the altitude of the plateau being seldom over 2,000 feet above the sea level, except along the Labrador Coast. In certain areas it is densely wooded, while also containing extensive clay belts of potential value for agricultural purposes.

The Arctic Archipelago.

The area of the Arctic Archipelago is over 500,000 square miles. In general, the tableland in the South has an elevation ranging from 2,000 feet to 3,000 feet, while northward it measures to about 5,000 feet. The elevated districts of the large Eastern Islands are largely underlain by pre-Cambrian strata, similar to those of the Laurentian plateau; while the lower areas are occupied by rocks of Palaeozoic and Mesozoic age. Little information is as yet available concerning the occurrence of economical minerals in the Arctic region. The existence of both gold and native copper is, however, reported, while mica, which occurs in quantity, is now being mined. Lignite also occurs in the Tertiary beds of the Northern and Eastern shores of Baffin Island and elsewhere, while the occurrence of bituminous coal of good quality in thin seams is also known.

The Interior Continental Plain.

Between the Laurentian Plateau region on the East and the Cordilleran Mountain system on the West is situated the Interior Continental Plain, embracing an enormous tract of comparatively level, rolling country, much of which is eminently suitable for agricultural uses. The Southern portion, in Alberta, represents 150,000 square miles of open grass land. To the North of the prairie country it is at first wooded, but farther North the area of forestation gradually diminishes. South of the 54th parallel the plains are divided into three parts by two lines of escarpment. The lower prairie level, that of the Red River Valley, has an average elevation of about 800 feet, and South of Lake Winnipeg comprises some 7,000 square miles of prairie land. To the West are a series of highlands, the summits rising from 500 to 1,000 feet above the level of the low plains to the East. The second prairie level, extending Westward 250 miles, has an average elevation of about 1,000 feet. The third level has a general elevation along its Eastern margin of 2,000 to 2,500 feet, but rising to over 4,000 feet in the West.

The Interior plain is for the most part underlain by undisturbed Cretaceous and Tertiary sediments. Along the Eastern margin, however, strata of Palaeozoic age rest directly on the pre-Cambrian formations, while Ordovician measures outcrop on the Western shores of Lake Winnipeg to the South. Further West these are underlain by Silurian beds, in turn covered by Devonian strata, outcropping near the foot of the Manitoba escarpment, where the cretaceous sediments overlap the Palaeozoic measures and extend Westward to the Rocky Mountains, and Northward for over 1,200 miles.

The economic mineral resources of the area include coal (lignite), which occurs within two horizons; gold, in numerous rivers; clay, iron, stone, salt, gypsum, building stones, clays, and cement materials; while natural gas has been found over wide areas. The lower sandstones of the Cretaceous, where outcropping along the Athabaska, are for many miles saturated with bitumen, probably averaging 12 per cent. in maltha or asphalthum, and, it is estimated, represent 4,700,000,000 tons of bitumen actually available. There are also promising indications of large oil fields in Northern Alberta.

The Cordilleran Region.

The Cordilleran Region is, in Canada, a continuation of a great mountain system, stretching from Mexico, along the Pacific border of the Continent into Alaska. It is pre-eminently characterized by the variety and wealth of its mineral resources. In Canada the region has a length of 1,300 and a width of 400 miles, and includes all of British Columbia, partes of Western Alberta, the whole of the Yukon Territory and a large tract in the adjacent Western portion of the North-West Territories, — an area approximately 600,000 square miles. Physiographically the region may be generally described as being exceptionally mountainous, and densely forested, but possessing as well wide stretches of open, grass-covered hills and valleys, noted for their fertility.

The geological history of the region, as a result of successive epochs of vulcanism and earth-movements, is extraordinarily complicated, and various formations ranging from the pre-Cambrian to those of recent deposition are widely displayed. The Rocky Mountains and the ranges of the Mackenzie system to the North are almost entirely composed of sedimentary measures, chiefly of Palaeozoic age, but in places including great thicknesses of stratified pre-Cambrian rocks. Directly West of the Rocky Mountains are the Gold ranges, embracing the Selkirks, the Purcell, the Columbia and the Cariboo Mountains, in which the prevailing rocks are pre-Cambrian and the older Palaeozoic rocks. Between the Rocky Mountains and the Coast Range, the country is underlain by Palaeozoic and early Mesozoic measures, much folded and faulted, and invaded by masses of Plutonic rocks. In Southern British Columbia large areas are occupied by Tertiary strata, while in the Northern section Cretaceous, with perhaps, late Jurassic beds prevail. The Coast range is essentially a complex batholith of granite rocks of Jurassic age, penetrating Triassic and older rocks.[1] The upper Mackenzie Valley is chiefly occupied by Devonian measures, while Devonian limestones and shales are present in the Rocky Mountain, Mackenzie Mountain systems, and in the Northern portion of the Yukon Territory. Carboniferous strata with, perhaps, conformably underlying Devonian beds, are extensive throughout Central British Columbia, continuing into the Yukon. In the Rocky Mountains usually the Carboniferous beds are directly overlain by Cretaceous strata. Ordovician limestones and Fossiliferous shales occur at wide intervals along the course of the Rocky Mountains, and also far North in the Mackenzie Mountains. So far Silurian measures have been recognized at one locality only.

Although but a very small and insignificant area in this region in Canada has as yet been prospected for minerals, it has already contributed virtually all the lead produced in the country, nearly all the gold, nearly three-quarters of the copper, a quarter or more of the coal, and a considerable proportion of the silver. According to Mr. R. W. Brock, Director of the Geological Survey, not one-twentieth part of the area has been prospected in detail; while not one area, however small, has been completely tested. In addition to the minerals mentioned, the following have been either produced or discovered: Platinum, mercury, iron, zinc, mica and building and ornamental stones.

NATURAL AND INDUSTRIAL CONDITIONS.

Natural conditions in Canada are on the whole distinctly favourable to mining enterprise. A vast section of the area lies within the temperate zone, and the climate is peculiarly salubrious and enjoyable throughout the year. Even in the more Northern latitudes, industry is not impeded to any serious degree by the cold or length of the winters. In this connection a few statements from official meteorological records may be of interest:

[1] Geology, and Economic Minerals of Canada, page 120.

Temperature.

The following table[1] gives the average number of days during the year when temperatures were above 32°, 50°, and 70° (Fahr.) respectively, at centres in each Province or Territory:

District	days above 32°	days above 50°,	days above 70°
Halifax, Nova Scotia	328	200	50
Montreal, Quebec	300	200	75
Winnipeg, Manitoba	250	200	100
Calgary, Alberta	300	175	50
Victoria, Br. Columbia	363	255	50
Dawson, Yukon	200	140	42

The mean annual temperatures are:

Halifax, N. S.	43,2 °
Montreal Que.	42,5 °
Winnipeg, Man.	33,5 °
Calgary, Alta.	37,5 °
Victoria, B. C.	47,5 °
Dawson, Y. T.	27,5 °

The Summer temperatures, North of Latitude 50°, in the East and to Latitude 70°, in the West has a mean of 50° (Fahr.) The mean Summer temperatures between latitudes 40° and 50°, vary between 55° and 65° (Fahr.)

Rainfall.

Halifax, N. S.	50″ — 55″
Montreal, Que.	35″
Winnipeg, Man.	20″ — 25″
Calgary, Alta.	15″
Victoria, B. C.	50″
Dawson, Y. T.	7″ — 9″

Snowfall.

Halifax, N. S.	60″
Montreal, Que.	120″
Winnipeg, Man.	30″ — 60″
Calgary, Alta.	30″ — 60″
Victoria, B. C.	—″
Dawson, Y. T.	50″ — 60″

(N. B. The snowfall on the Western slopes of the mountains in British Columbia is very heavy, being probably not less than 130″.)

Sunshine.

The whole of Canada, except the region near the coast of British Columbia, is favoured with more sunshine than any portion of Great Britain, Germany, Holland, or northern France. Nearly all parts of the Dominion have an annual percentage of over 40, and a summer percentage of between 53 and 59, whereas it is only the more southern part of England that a normal percentage of 36 is reached, and the summer figures, while in a few instances up to 50, are more generally between 35 and 45. At German stations the August maximum averages under 50%; and in a few cases reaches 52. In the south of Europe much higher values are obtained: Vienna, 54; Zurich, 57; Trieste, 66; Lugano, 67; Rome, 75; Madrid, 84. Thus only the southern parts of Europe have more sunshine than Canada. The most salient feature of Canada's climate is not the cold of winter, but the perfection of the summer and autumn.[2]

WATER POWERS.

The economic importance of the great river systems of Canada, both as affording means of cheap transport and as source for the development of water powers, has already been emphasized. Exact data, however, in respect of Canadian waterpower resources is not as yet available

[1] Compiled from isotherm data.

[2] Extract from paper „The Canadian Climate", read by R. F. Stupart, Toronto, before the eighth International Geological Congress.

except possibly as regards those in certain well-settled areas. Meanwhile the following figures, though incomplete, will serve to direct attention to developments in this direction:

Province	Possible H. P. Development	Amount Developed
Nova Scotia	54,300	13,330
New Brunswick	150,000	
Quebec	17,075,939	50,000
Ontario	6,190,000	350,000
Manitoba	495,000	18,000
North West Territories	600,000	
Saskatchewan	500,000	
Alberta	1,144,000	1,330
[1] British Columbia	2,065,500	73,100

In practically all the great centres of mining activity hydro-electric power is utilized. The most notable installation, perhaps, is that at Bonnington Falls, near Nelson in British Columbia, where 40,000 horse power has been developed and is transmitted to mines and smelters within a radius of over 80 miles. This development, it may be remarked, by making cheap power available

Water Powers of Canada, Upper Bonnington Falls, near Nelson, B. C.

to the mines, has contributed in a very large measure to the solution of the problem of the profitable operation of the large "low-grade" ore bodies of the Rossland and Boundary districts.

[1] With the exception of the returns from the Provinces of Que. and Ont., the figures here presented were kindly supplied by Mr. Jas. White, Secretary of the Commission of Conservation, Ottawa.

Power plant on Spanish River, at which power is generated to operate the nickel mines and smelters at Copper Cliff, Ontario.

TIMBER.

Except in the extreme North, as also in regions of prairie country in the middle West where timber is somewhat scarce and its growth confined to river courses, it may be broadly stated that in those districts in which mining operations are, or are likely to be carried on, a plentiful supply of timber suitable for mining purposes will be readily available for many years to come; although it must be admitted that in certain localities as a result of forest fires, wasteful cuting, and improvidence generally, reserves have been badly diminished. In the Eastern Provinces tamarack and spruce is chiefly used for mine purposes; in Ontario the best results have been obtained with elm; while in the West pine and Douglas fir are mainly employed for props, and cedar, when obtainable, for lagging. In a paper[1] read recently before the Canadian Mining Institute, Dr. B. E. Fernow, Dean of the faculty of Forestry of Toronto University, observed, however, that Canadian mines apparently use very little timber, in consequence of favourable conditions of rock in most localities, the roofs requiring little support. From recent information the average consumption appears to be between one and eight cubic feet of wood per ton of ore mined. At one colliery in British Columbia 3,000,000 lineal feet of props and ties are annually required, at a cost of from 1—$^3/_4$ to 6 cents per lineal foot; in West Kootenay districts, British Columbia, the cost of timber varies from 8 to 12 cents per cubic foot; in Nova Scotia, from 3 to 5 per cubic foot for stulls and poles, and 6 to 12 for better class timber. These figures are merely quoted as suggestive of prevailing conditions.

MINING LAWS.

By the provisions made at the time of the Canadian Confederation, the Provinces then existing, including Nova Scotia, New Brunswick, Quebec, Ontario and subsequently British Columbia, retained the regalian rights to and jurisdiction over minerals within their boundaries. Consequently a distinctive law governing the acquisition and operation of mining lands obtains in each of these provinces, differing either fundamentally or in detail. In the Provinces of Manitoba, Saskatchewan, Alberta, the North-West Territories, and the Yukon Territory, however, mining is controlled and regulated by Federal Government enactments. In general, the terms under which title is granted are peculiarly easy, the aim of legislature being to promote to the utmost the development and utilization of the mineral resources of the country. The several sets of laws in force may be briefly summarized as follows:

Dominion Regulations (Applicable to Manitoba, Saskatchewan, Alberta, the North-West Territories, Yukon Territory etc.).

Coal Lands: Areas, not exceeding 2,560 acres, may be leased for a term of 21 years, at an annual rental of $ 1.00 per acre payable yearly in advance. The lease is conditional upon the commencement of active operations within one year from a prescribed date.

[1] The Relation of Mining to Forestry, B. E. Fernow, Can. Mining Inst., Vol. XII, pages 371—6.

Royalty is levied at the rate of 5 cents per short ton on the merchantable output.

Quartz Claims. Every person over 18 years of age has the right to prospect for minerals and locate claims upon any vacant Dominion lands, or lands whereon the gold or silver has been reserved to the Crown. To hold the claim from year to year, work to the value of $ 100.00 must be performed thereon, or the cash equivalent paid to the Government.

Freehold title or "Crown grant" may be obtained after the sum of $ 500.00 has been expended in the development of the claim, or a cash payment of $ 500.00 made to the Government. The size of a mineral claim is limited to 1,500 feet square. The Crown reserves the right to levy a Royalty not exceeding 2—$^1/_2$% of the products of the location.

Placer Claims. (Yukon) — Any person over 18 years of age may locate. Claims may not exceed 800 feet measured along base line of creek, by 1,000 feet. Title — grant renewable from year to year, conditional on the performance of work to the value of $ 200.00 per annum.

Royalty. — At the rate of 2—$^1/_2$% of the value of the output.

Dredging. — Title, Leasehold for term of fifteen years, renewable at discretion of Government at rental of $ 100.00 per mile for first year, and $ 10.00 for each subsequent year. Within three years from date of lease at least one dredge of sufficient capacity must be in operation, and work continued for not less than fifty days each year. Royalties — at the rate of 2—$^1/_2$ per cent no gold recovered.

Nova Scotia.

Coal, Iron and Other Minerals (exclusive of gold and silver): Title-License to search or leasehold. A license (fee $ 50) entitles holder to exclusive rights to prospect over any single tract not exceeding 5 square miles and not over 2—$^1/_2$ miles in length.

Leases are granted for a term of 20 years, renewable for further like periods. Annual rental $ 30.00 per tract. Coal and iron tracts covered by lease may not exceed one square mile; copper or lead, one-half square mile; tin or precious stones, one-quarter square miles. Royalties are imposed as follows: Coal, 10 c per long ton removed from mine or used in manufacture of coke; copper, 4 c per unit of copper sold; lead, 2 c per unit sold; iron, 5 c per long ton; tin, precious stones and unspecified minerals, 5% of their value.

Gold and Silver. Areas are laid off in plots of 250 × 150 feet. Any number up to 100 of these areas may be secured under a license to prospect for twelve months on payment of 50 c per area. During the life of the license, areas may be leased, or direct application may be made for a lease, at a rental of $ 2.00 per area for the first year, and 50 c per area thereafter. Royalties — 2% of the gross value.

New Brunswick.

General principles and provisions similar to those of Nova Scotia.

Quebec.

Any person holding a »miner's certificate« (fee $ 10.00 per annum) may prospect and locate claims. When a claim has been »staked«, notice must be given to the authorities. Within four months from the date of staking a mining license must be applied for. Licensee (fee $ 10.00) is entitled to a claim of from 40 to 200 acres in unsurveyed territory; and from 100 to 200 acres in surveyed territory upon payment at the rate of $ 1.00 per acre. The license is renewable from year to year. Title in fee may be obtained by purchase, at a minimum rate of $ 10.00 per acre and a maximum rate of $ 20.00 (according to the proximity of a railway), but no one person in the same year is entitled to purchase a concession of over 400 acres within a 100 mile radius.

Royalties — On placer gold, at a rate not exceeding 3% of the net value of the output. In respect of other minerals the Crown reserves the right to levy royalties.

Ontario.

Lode Mines. Any person over eighteen years of age holding a miner's license (fee $ 10.00), may prospect for minerals and stake out claims in unreserved territory. Before, however, a claim may be legally „located", valuable mineral in place must have been discovered thereon. The size of claims vary in accordance with local survey requirements. In a section declared to be a „Special Mining Division", a mining claim must be a square of 40 acres; elsewhere from 37—$^1/_2$ to 50 acres. The boundaries of all claims extend downwards vertically on all sides; not more than three claims may be staked in the name of any one licensee in any one mining division or other territory in the one year. Special permits to prospect, giving the licensee exclusive rights to occupy a block of land within certain boundaries for a defined period of time, are also granted. Actual mining operations must be commenced and carried on continuously within three months of the date of recording

for a period of thirty days; during the next two following years, sixty days' work in each year is required; and during the third year, ninety day's work. Fulfillment of these conditions entitles the licensee to a „Certificate of Performance". A freehold patent — „Crown Grant" — may then be obtained upon payment at the rate of $ 3.00 per acre for the mining rights of the lands in surveyed territory, and at the rate of $ 2.50 per acre in unsurveyed territory. Before a patent is issued, the claim must, however, be surveyed at the expense of the applicant.

Placer Mining. General provisions of the Mining Act apply.

Dredging. Title — Leasehold for ten years renewable for a further term of ten years. Rental, not less than $ 20.00 per mile in length of any river, stream or lake.

Petroleum, gas, coal, and salt. Boring permits (fee $ 100.00) granting exclusive rights to prospect in defined areas are granted, and are good for one year. Boring operations must be commenced within two months from the granting of the permit, and during its term exploration work must be performed to the value of not less than $ 2.00 per acre. The permit is renewable on the same conditions. Title — Leasehold; but only granted upon proof of actual discovery. A lease is granted for a term of ten years at an annual rental of $ 1.00 per acre, subject to the performance of operations to the value of not less than $ 2.00 per acre. It is renewable on the same terms for a further period of ten years, and for a third term of twenty years at such renewal rental as may be agreed upon or provided by Statute or regulation.

British Columbia.

Lode Mines. Any person over the age of eighteen years holding a miner's certificate, (fee $ 5.00) may prospect for minerals and locate claims and mine on Crown lands or on lands on which the mineral rights are reserved. Only one claim may be located by the licensee on the same vein or lode The size of claim is limited to 1,500 feet square (approximately 52 acres). The claim may be held from year to year on condition of performance of work to the value of $ 100.00, or payment to the Crown of a sum of money to that amount in each year. The actual cost of the Survey of a claim not exceeding $ 100.00 is allowed to apply as „representation" work. If, during any year, work done represents a greater expenditure than $ 100.00, any further sum of $ 100.00 may be officially recorded. When $ 500.00 has been expended on the development of a claim, or that sum paid to the Government, a Crown Grant, providing freehold title, may be applied for (fee $ 25.00).

Placer Mining. Persons over eighteen years of age holding a miner's certificate may locate one claim on each separate creek, ravine, hill, or bar diggings. Creek Claims — 250 feet long measured in the direction of the general course of the stream, and 1,000 feet wide, measured from the general course of the stream, 500 feet on either side of the centre thereof. Bar Diggings — (a) not exceeding 250 feet square at any bar covered at high water; or (b) a strip of 250 feet of land at high water mark, and in width extending from high water mark to extreme low water mark. In clay diggings a claim is 250 feet square. (Discoverer's claims are 600 feet in length to one person, or 1 000 feet to two). Claims are as nearly as possible rectangular in form, marked by four corner posts. Title — (1) Conditional on continuous operation, except during the close season, lay-over, or leave of absence, or for some other reasonable excuse which shall be shown to the satisfaction of the gold commissioner. (2) Leasehold — 20 years period on terms and conditions prescribed by the gold commissioner. Areas not to exceed, Creek claims, half a mile; hydraulic diggings, 80 acres; for dredging leases, 5 miles; precious stone diggings, 10 acres. Minimum rentals for a creek lease is $ 75.00 per annum, and for a hydraulic lease, $ 50.00 per annum, with a condition that at least $ 1,000.00 per annum shall be spent in development.

Dredging. Title, Leasehold for 20 years. — Bed of any river below low water mark. For dredging leases the usual rental is $ 50.00 per mile per annum, and operations to the value of $ 1 000.00 per mile per annum must be performed.

Taxation. — At the rate of 2% per annum, payable quarterly, on the assessed value of output over $ 5,000. The gross output of placer and dredging mines to the value of $ 2 000 in any one year are exempt from taxation.

Coal. — License to prospect. Applicant must have staked out an area by placing stakes at the four corners thereof, and advertised his intention to apply for such license in the official gazette and in a local paper. Within two months from the publication of such notice, application must be made to the Assistant Commissioner of lands and works for the district for a prospecting license. This license covers a term not exceeding one year. The fee is $ 100.00. The area covered by each license must be rectangular in shape, and cannot exceed 640 acres, measuring eighty chains by eight chains. The lines must run true North and South, and true East and West. The licences are renewable for second and third years on condition of *bona fide* exploration. The licenses are not

transferable. Title — Leasehold and freehold upon evidence of discovery. Areas may be leased for a term of five years at an annual rental of 15 c per acre. Then at the end of five years, provided mining operations have been continuously and vigorously prosecuted, the lands, including surface rights, may be purchased at the rate of $10.00 per acre; or if the mining rights only for $5.00 per acre. A royalty of 5 c per long ton of merchantable coal raised is imposed.

Petroleum. —License to prospect for and title as provided in the case of coal.

Royalty. 2—1/2 c per barrel containing 35 imperial gallons on all crude petroleum raised.

IMPORTS OF MINING MACHINERY.

While the manufacture of machinery for mining purposes in Canada is becoming an increasingly important industry, and a number of the large manufacturing establishments of the United States have of late established factories in the Dominion, the imports of machinery continue to be considerable. For purposes of comparison the following tabulated statement, which also further indicates the progress of the mining industry, may be of interest: Value of Mining Machinery imported into Canada in the fiscal years 1890, 1900 and 1909:

Country	1890	1900	1909
	$	$	$
Great Britain	6,182.	43,660.	127,187.
United States	15,566.	678,065.	687,468.
Germany	...	...	49,102.
Belgium	...	...	1,168.
Sweden	...	...	761.
France	...	156.	...
B. W. Indies	...	61.	...
	21,748.	721,942.	865,686.

List of Items Admitted into Canada Free of Duty.

Sundry articles of metal as follows, when for use exclusively in mining or metallurgical operations, viz.: — Diamond drills, not including the motive power; coal cutting machines, except percusion coal cutters; coal heading machines; coal augers; rotary coal drills; core drills; Miners' safety lamps and parts thereof, also accessories for cleaning, filling and testing such lamps; electric or magnetic machines for separating or concentrating iron ores; furnaces for the smelting of copper, zinc, and nickel ores; converting apparatus for metallurgical processes in metals; copper plates, plated or not; machinery for extraction of precious metals by the chlorination or cyanide processes; amalgam safes; automatic ore samplers; automatic feeders; retorts; mercury pumps; pyrometers; bullion furnaces; amalgam cleaners; blast furnace blowing machines; wrought iron tubing, butt or lap welded, threaded or coupled or not, over four inches in diameter; and intregral parts of all machinery mentioned in this item.

Machinery and appliances of iron or steel, of a class or kind not made in Canada, and elevators, and machinery of floating dredges, when for use exclusively in alluvial gold mining.

Iron or steel pipe not butt or welded, and wirebound wooden pipe, not less than thirty inches internal diameter, when for use exclusively in alluvial gold mining.

Blowers of iron or steel of a class or kind not made in Canada, for use in the smelting of ores, or in the reduction, separation or refining of metals; rotary kilns, revolving roasters and furnaces of metal of a class and kind not made in Canada, designed for roasting ore, mineral, rock or clay; furnace slag trucks and slag pots of a class or kind not made in Canada.

Briquette-making machines.

RESOURCES AND INDUSTRY.

COAL.

The extensive coal areas of Canada are found in the Provinces of Nova Scotia and New Brunswick, in the East; and in the Provinces of Saskatchewan. Alberta and British Columbia, and in the Yukon Territory, in the West. The Eastern measures occur in the Carboniferous formation; while those of central and Western Canada are found in the Cretaceous and Tertiary. The eastern coal is entirely Bituminous, the central chiefly Lignite, while in Western Alberta, British Columbia and the Yukon it ranges in character from a high grade Lignite to Anthracite. Lignites of still more recent age occur in Ontario. Average

analyses of Canadian coals from the respective areas are shown in the following table compiled for the writer by Mr. Edgar Stansfield, M. Sc., of McGill University, Montreal:

Coal Field	Moisture left in air dry coal	Fixed Carbon	Volatile Matter	Ash	Sulphur in dry coal	Calorific value of dry coal. calries
		Proximate analysis of dried coal.				
	%	%	%	%	%	
Sydney Field	2.6	57	36	7	2.4	7 600
Pictou Field	1.7	57	30	13	1.2	7 200
Souris Field	18.1	45	44	11	0.6	5 750
Edmonton Field . . .	19.0	50	40	10	0.4	6 100
Frank-Blairmore Field .	0.8	57	26	17	0.6	6 850
Crow's Nest Field . . .	0.9	64	25	11	0.5	7 450
Cascade Field	0.7	72	15	13	0.7	7 200
Nanaimo-Comox Field .	1.5	51	38	11	0.9	7 150

Nova Scotia Coal Areas. The Coal Districts of Nova Scotia in which active mining operations are conducted, number five, of which the Sydney coal field, whose output represents 71.9 per cent of the aggregate annual output, is the most productively important. The measures, it is estimated, underlie a land area of about fifty-seven square miles, while a large area under the sea is also worked. The strata dip very gradually about 7%, and are practically free from faults of any magnitude. The exposed section of the productive coal measures represents about 1,800 feet, and the strata largely composed of shales and sandstones, contain from forty to fifty feet of coal, in twenty-four seams, of which six are four feet or more in thickness. The largest seam is known as the "Phalen", and is 8 feet, 7 inches in thickness.

Other Nova Scotian fields are those of Inverness — a series of narrow areas extending for over fifty miles along the Western shore of Cape Breton Island — at present producing 6% of the coal mined; Pictou County, having an area of about 25 square miles and producing 12.7%; and Cumberland County, having a total area of about 350 square miles and producing 8.8%. The Grand Lake field in New Brunswick is also productive, but not importantly so; while coal of a less superior quality has been mined from large seams in Richmond County, Cape Breton.

The largest seams worked in Nova Scotia are those found in the Pictou field; one seam being here 38 feet in thickness, a second, from 22 feet in thickness to 38 feet, and a third, 13 feet to 20 feet in thickness.

Approximate analyses of the Nova Scotia coals are given in the following returns:[1]

Sydney Field (from Phalen Seam).

Fixed Carbon	58.5%
Volatile Matter	32.2%
Ash	7.1%
Sulphur	2.2%
	100.0%

Cumberland Field (Springhill Colliery).

Fixed Carbon	62.78%
Volatile Matter	28.55%
Moisture	3.66%
Ash	4.32%
Sulphur	1.26%

Inverness Field.

Fixed Carbon	47.04%
Volatile Matter	42.16%
Ash	10.80%
Sulphur	5.04%

Pictou Field (Acadia Colliery).

Fixed Carbon	61.15% — 60.77%
Volatile Matter	29.20% — 28.09%
Ash	7.55% — 9.99%
Sulhphur	1.48% — 1.24%
Moisture	2.10% — 1.15%

[1] Report Mining and Metallurgical industies of Canada. Dept. Mines Ottowa, 1907.

Methods of Working. — At seven of the collieries operated by the Dominion Coal Company in the Sydney field, the seams are reached by means of shafts. At the three remaining collieries, entry is by slopes or main deeps. In general, the pillar and room system of mining is employed, although in five collieries in Nova Scotia the method of working by the long wall system is followed. While the Cape Breton mines are comparatively free from gas, safety lamps are in universal use in the Collieres of the Province. Compressed air and electric locomotives, as well as the endless rope system, are employed in the principal collieries for coal haulage; while compressed air is also used to operate coal-cutting machines. A recent innovation at the Dominion Coal Company's collieries, worthy of remark, is the installation — the first in Canada — of life saving apparatus of the Draeger type.

The bulk of the coal produced in Nova Scotia is marketed in Eastern Canada, while the balance is sold in the United States. The cost of the coal (including the Royalty impost of 12—$^4/_2$ cents), loaded on steamers at Sydney, is estimated at approximately $ 1.75 per ton. The sale price in the St. Lawrence market is $ 2.85 per ton.

Labour. — The number of men employed in the Nova Scotia collieries in 1908 was 12,933, of which 6,567 represented skilled labour. The miners in the larger collieries in the Cape British area work on a contract basis and are paid according to an agreed schedule,[1] as follows:

Machine Cut Coal.

Cutting	9.5	cents to		12.1	cents
Loading	11.5	,,	,,	13	,,
Shot-firing	9.5	,,	,,	12	,,
Total for rooms	31.5	,,	,,	41	,,
Deeps	39.5	,,	,,	52.5	,,
Levels	36.3	,,	,,	49.5	,,
Cross cuts, per lineal yard in addition to room prices	12.5	,,			

Hand Cut Coal.

Rooms	49	cents to		51.5	cents
Deeps	62	,,	,,	76	,,
Headways or slants	56	,,	,,	63	,,
Levels	54.5	,,	,,	62	,,
Pillars	46	,,	,,	48	,,

Cross cuts per lineal foot.

Up to 12 feet	32.4	cents
Up to 15 ,,	25.6	,,
Over 15 ,,	33.0	,,
Up to 20 ,,	27.0	,,
Over 12 ,, & up to 21 feet	45.6	,,
Over 20 ,,	33.0	,,
Over 21 ,,	50.0	,,

The average earnings of miners in one field in 1909 is said to have been between $ 2.81 to $ 2.97 a day.

Manitoba and Saskatchewan. No coal mining has been undertaken in Manitoba for some years past; although in the near future the exploitation of some of the areas is anticipated.

In Saskatchewan, especially in the southern section, lignite seams outcrop in numerous localities on the borders of the areas of Tertiary beds constituting the elevated districts. Some of these seams are of considerable magnitude. The average thickness of seams worked is, however, five feet. Activity at present is chiefly confined to operations in the Souris River area, between Estevan and Bienfait, sufficient production being maintained from six collieries to supply local market needs. The coal is reached both by shaft and slope, and in some cases by level entry, the room and pillar method of mining being employed. The mines are practically non-gaseous, permitting naked lights to be used with impunity. The coal output during the year from March 1908 to March 1909 was 169,732 tons, the industry employing 357 men

Alberta. The productive coal horizons in the Province of Alberta are those known as, respectively, the Kootanie, or lowest horizon; the Belly River, or middle horizon; and the Edmonton or Laramie. The Kootanie measures include the extensive and valuable Elk River (partly in British Columbia), Crow's Nest (Coleman-Blairmore areas), and Cascade Basins. In the Elk River basin, 22 workable seams, containing 216 feet of coal are known; in the Crow's

[1] This schedule differs in respect of each colliery.

Nest, 21 seams, containing 125 feet of coal; and in the Cascade area, 25 to 29 workable seams, containing from 189 to 214 feet of coal. The Belly River measures include, in Alberta, the Lethbridge area; while even larger coal areas in the Province belong to the Laramie. The extraordinary rapidity with which the Albertan coal industry is developing is indicated by the fact that although its history scarcelly covers a longer period than ten years, there are now no less than one hundred and twenty-one mines in operation; while in 1909 thirty-two new mines were opened. Again, last year two large new coal areas in the bituminous field were proven, namely the Brazeau area, west of Edmonton, and contiguous to the line of the Grand Trunk Pacific railway; and the South Fork area, south of the Crow's Nest Branch of the Canadian Pacific Railway, south-west of Frank. Of this latter area, the Inspector of Mines of the Province of Alberta remarks that it is now proved to be larger and will eventually be more important than the Frank-Coleman area in which collieries are at present in successful operation. There is an excellent market for all the coal produced throughout the north-west, a large proportion being used for domestic requirements, and the remainder for fuel or locomotives and steam purposes generally. The coal is reached by shafts and slopes, while the common method of mining is »pillar and stall«. All the larger collieries are magnificiently equipped. A general statement concerning production appears elsewhere. More precise information may, however, be of interest, and to this end the following comparative figures in respect of coal, coke and briquette output during 1908 and 1909, respectively, are presented:

	1908	1909	Increase
Coal	1,845,000 tons	2,174,329 tons	17.85%
Coke	75,657 ,,	87,812 ,,	16.07%
Briquettes	36,261 ,,	89,785 ,,	147.60%

The output of coal may be classified under:

Bituminous	1,197,399 tons
Lignite	763,673 ,,
Anthracite	213,257 ,,

It may be further noted that the 1909 output represents an increase of 168.03% over that of only five years ago.

Labour. The average number of men employed in the mines last year was 5,207. Miners' wages are $ 3.50 a day of eight hours; helpers, $ 2.75 to $ 3.00, and underground labourers, $ 2.00 a day of eight hours. Men employed on surface work receive from $ 2.00 to $ 3.25 a day of ten hours.

It was recently reported that the Government of Alberta contemplates installing rescue stations at all the principal mining centres of the Province. This is instanced as evidence of the interest of the Provincial Administration in the welfare of the mining industry.

British Columbia. Coal mining continues to occupy the premier position among the productive mining industries of British Columbia, the output in 1909 reaching the considerable value of approximately $ 6.800,000 for coal, and $ 1,700,000. for coke, or an increase over the returns of 1908 of about a million dollars. Practically all the coal mined is bituminous of excellent quality, much of it being eminently suitable for steam raising and coking purposes.

The distribution of coal in British Columbia is very wide, but the areas at present extensively worked are those of the Crow's Nest Pass district in the Rocky Mountain section, and the coal fields on Vancouver Island. In both areas the coal is of Cretaceous age, the measures in the Rocky Mountains area occuring as basins amongst the folded and faulted Palaeozoic and Mesozoic strata; while in the Nanaimo-Comox fields on Vancouver Island the seams are found in the upper part of the Cretaceous. A third coal area, from which coal is also produced, is that of the Nicola Valley, a district in the south-west portion of the Province. Here the coal is I ignite, and of Tertiary age, occurring in very thick seams, sometimes as great as eighteen feet.

The important collieries of Fernie and Michel are established on seams within the boundaries of the Elk River Basin, already referred to, the southern portion of which has an area of about 300 square miles and extends eastward into the Province of Alberta. In this basin many of the seams are fifteen and more feet in thickness. In one section no less than 62 seams of coal have been proven. In the Comox field, which has an estimated area of approximately 300 square miles, at one mine worked the ten seams have an aggregate thickness of 29 feet, the thickest seam measuring ten feet. In the Nanaino field coal is extracted from two seams, one of which varies in thickness from five to twenty feet, and the other from three to five feet. The machinery equipment at all the collieries is thoroughly modern, and most complete, and it may be mentioned in this regard that at one colliery alone, in the Crow's Nest area, an expenditure, it is

reported, has been made on account of recently completed equipment of upwards of a million dollars. About 40% of the coal raised is exported chiefly to the United States, the remainder being sold for home consumption. The coke made in the Crow's Nest area is of the highest quality.

In 1908 the industry gave employment to 6,073 persons. The scale of wages paid to miners is much the same as that usual in the Alberta mines; although in several of the collieries the contract system is followed, payment being made on a tonnage basis.

GOLD.

Gold has been discovered and mined in all the Provinces and Territories of the Dominion, with the exception only of Manitoba. In Nova Scotia, gold occurs, both in quartz veins and in association with antimony; in New Brunswick and Quebec both in quartz veins and in alluvial deposits; in Ontario, in quartz veins, and at times as an associated mineral with nispickel, pyrite, magnetite, chalcopyrite and pyrrhotite; in Saskatchewan and Alberta, in alluvial deposits; in British Columbia, in alluvial deposits, in quartz veins, as free gold associated with pyrite, galena and zinc blende, with argentiferous tetrahedrite, galena, zinc blende, iron and copper sulphides, in schistose pyritiferous diabase, and in copper-gold deposits; and in the Yukon territory, in pre-glacial and more recent alluvial deposits, and in quartz veins.

NOVA SCOTIA. The gold-bearing series of Nova Scotia, a group of sedimentary rocks intruded by dikes and batholiths of granite, have a very wide distribution, occupying, it is estimated, an area of approximately 8,500 square miles. They consist of two groups, an upper of dark slates, and a lower of quartzites, in which latter the auriferous quartz, — dominantly bedded veins — occur usually at points along the anticlinal axes of folding, and, under certain stratigraphical conditions, are localized along the crowns of the arches, resulting in a series of superimposed saddle reefs — an occurrence very similar to that met with in the Bendigo gold field, Australia. Some of these reefs attain maximum thicknesses of from fifteen to twenty feet or over, but quickly diminish in size on either side of the fold, — According to a report made by an official of the Nova Scotia Department of Mines, they also extend in many cases for thousands of feet, and have been followed to depths of seven hundred feet in their vertical extension. The veins occuring to one side of the anticlinal axes, as a rule within a zone of from 200 to 1,000 feet wide, usually average in width from four to twelve inches. Another class of veins also occur cutting the planes of stratification at various angles. The gold that is within the zone of oxidation generally occurs in the free state as filaments, leaves and nuggets, or as very fine invisible particles is distributed through the veins, but more commonly is locally concentrated towards the centre of the zones of quartz veins; while the longer gold particles are as a rule found at points of local enrichment. Gold was first discovered in 1860, and operations have been carried on continuously, but in no one instance on a large scale, since 1862. The annual yields have fluctuated in value between, in round figures, $ 200.000 and $ 600.000, the total production to September 1908 being $ 16,887,670. In 1909, the annual production increased to $ 218,000. The average value covering the whole of the period during which the mines have been operated is $ 8.97 per ton of ore crushed.

Mining and Milling Costs. Returns from a representative enterprise show the average cost of mining to have been $ 2.44 per ton; and of milling 63 c per ton. Mining costs, however, vary between $ 2.00 and $ 4.00 per ton, and milling costs between 50 c and $ 1.00 per ton, according to the width of the vein and the tonnage treated. In all cases the gold is extracted by crushing and amalgamation; but at some mines cyaniding is a supplementary process.

Labour. Miners are paid at the rate of $ 1.75 per day; muckers, $ 1.40 per day; mill-men, from $ 1.50 to $ 2.00; and engineers, $ 2.50.

QUEBEC. No gold production is at present shown from the Province of Quebec, although within recent months preparations have been made to extensively work the auriferous gravels of the pre-glacial streams in the Valley of the Chaudiere and in the neighbourhood of the Gilbert River, in which localities gold to the value of approximately three million dollars was won, chiefly between the years 1860 and 1876. Small values in gold are also contained in the chalcopyritic deposits of the Eastern Townships.

ONTARIO. Gold as so far found occurs in both Eastern and Western Ontario in numerous localities, both in the free state, in quartz cutting schists and basic igneous rocks and in association with mispickel, pyrite and pyrrhotite, with which the quartz is frequently impregnated. Although for a brief period a considerable production, reaching a maximum of nearly half a million dollars in 1899, was maintained, and industrial possibilities appeared favourable, subsequent operations

proved discouraging, and comparatively few mines are now being worked. A new gold district, known as the Porcupine, situated North of the height of land between Hudson Bay and the Great Lakes, has recently been discovered. The gold here occurs in veins three feet and upwards in width, the surface indications being unusually promising. It is, however, yet too early to offer any opinion concerning the probable permanence of the occurrences or of the productivity of the area. In 1909 the gold production of Ontario was but 2,042 ounces, the major proportion of which was derived from one mine in the Wabigoon district. It may, however, be noted that a large and apparently important deposit has been quite recently opened near Sudbury, on which a considerable expenditure, not far short probably of a quarter of a million dollars, has been made on account of development and equipment; and in consequence production from this mine will, it is expected ere long, add measurably to the annual gold output of the Province.

Labour. Muckers are paid from $ 1.75 to $ 2.25 per day; helpers, $ 2.25 to 2.75; miners, $ 2.75 to $ 3.50; blacksmiths, $ 3.00 to $ 4.50; engineers $ 2.00 to $ 3.00.

BRITISH COLUMBIA. At the close of 1909 British Columbia was credited with having produced since the inception of the industry in 1858, gold to the value of $ 126,317,200. of which rather more than one-half was derived from the placer mines. The gold production from this Province last year was probably at least 95% of the total yield from the several Canadian Provinces, or over 55% of the aggregate gold output of the Dominion, which last calculation takes into consideration production contributed from the Yukon Territory, now occupying the second place in point of productivity among the gold yielding regions of the country.

A placer claim on Spruce Creek, Atlin District, British Columbia.

The placers of the Province are pre-glacial sands and gravels, and the more recent deposits originating therefrom. In quartz, gold occurs (1) as auriferous mispickel, with copper and iron pyrites, in bodies replacing country rock, or near the contact of igneous rocks of dioritic inclination

and in a gangue of garnet, epidote, calcite, etc., (2) as free gold, in quartz veins cutting carbonaceous phyllites. Here the associated minerals may be pyrite, galena, zinc blende, and argentiferous tetrahedrite, (3) as free gold in schistose pyritiferous diabase, and in quartz veins carrying mispickel, galena and pyrite; and (4) in copper-gold deposits, such as those of the Boundary, Rossland, and the Coast districts, to which more specific reference will be presently made.

Between the years 1858 and 1894 the gold won in British Columbia was derived almost entirely from placer sources. In 1895, however, the lode mines, which only two years previously had become productive, contributed a gold yield of nearly twice the value produced from the placer mining districts; and since that time, notwithstanding that rich new placer fields were discovered and worked, by far the major proportion of the Province's annual gold production is traceable to lode mining operations.

The principal placer gold areas are those of the Cariboo district, about 285 miles North of the mainline of the C. P. R., at Ashcroft, and within the drainage basin of the Fraser River; localities in the Omineca district, still further North; and again those of the Cassiar Division, including the gold fields of the Atlin District to the extreme North-West of the Province. Mining is also carried on in other localities, but to a less important degree. In passing, it may be noted that the Cariboo mines as so far worked all occur in a relatively restricted area in the vicinity of Barkerville, and in the basin of the Quesnel River. The production from this region to date represents a value approximately of forty million dollars, and the remarkable richness of the field may be gauged from the fact that certain claims on the creek have yielded an average value of $ 1,075 per lineal foot; while from another creek gold to the value of $ 2,179,272 has been recovered. The Atlin district ,first actively worked in 1899, has to the present produced gold to the value of six million dollars[1], or the equivalent of a *per capita* annual output of a thousand dollars.

Pine Creek, one of the gold producing streams of the Atlin district, B. C.

Methods of working etc. Gold is recovered in the placer mining districts by ordinary sluicing and hydraulicing methods, and by dredging. This last, however, has proved as yet only moderately successful. Steam shovels have been employed in one or two instances to good advantage. The working season continues as a rule from late in April to the beginning or middle of November. Labour costs are relatively high. In the Atlin district the customary wage for miners is $ 5.00 a day; but in the Cariboo district it is somewhat less.

[1] Mining in Atlin, B. C., Rosalind Watson Young, M. A., Journal Canadian Mining Institute, Vol. XII, page 478.

Hydraulic Mining, Atlin District, B. C.

The principal occurrence of free milling gold ores, now being worked, are at Hedley, in the Similkameen district, at Camborne and Fish Creek in the Lardeau district, and in the Nelson district. At Hedley the occurrence is somewhat unusual, the ore being an auriferous mispickel, in a gangue of garnet, epidote and calcite, the width of the workable deposit being between 20 and 50 feet. This mine has yielded very handsome profits. No special comment is necessary in reference to mining and milling practice, which presents no unusual features. In a few instances cyanidation is employed as a supplementary process to crushing and amalgamation; and in some cases concentrates are produced and sent to local smelters for final treatment. In the Lardeau district milling costs are in the neighbourhood of 60 c per ton, and of mining and milling combined, $ 4.01 per ton. At a Nelson[1] mine the average costs of mining are reported to be $ 3.11 per ton, and of milling, $ 1.90 per ton.

Quite the bulk of the gold annually recovered from lode mining in British Columbia originated, however, from the copper-gold mines of Rossland, Boundary and the Coast districts, as already mentioned; for while the gold values in these ores are, with the exception of those in the Rossland ores, very small, yet as a result of the considerable tonnage mined, the gold yield from these sources represents a very large proportion, possibly amounting to nearly 20%, of the value of the annual aggregate mineral production of the Province. The following table shows the gold yield for 1908 from these districts:

	oz.	*value* $
Rossland	142,314	2,941,630
Boundary	91,551	1,892,359.
Coast Districts	2,492	51,510.

Yukon. The gold fields of the Yukon are included in an area of about 800 square miles, bounded on the West by the Yukon River; on the East by Dominion Creek, a tributory of the Indian River. The region is a series of long branching ridges, the average elevation of which, above the valley, is 2,000 feet or 3,200 feet above the sea level. The rock formation is very complex, presenting extreme variety in structure and composition, and ranging in age through the greater part of the geological scale. What is known as the Klondike region is within the unglaciated region of the Yukon, and is part of the upraised, dissected Yukon peneplain.

[1] Report of the Mining and Metallurgical Industries of Canada, 1907—8, Mines Branch, Dept. of Mines, Ottawa, page 121.

Head frames of two of the important gold-copper mines in the Rossland District, B. C.

According to Mr. J. B. Tyrrell,[1] a distinguished Canadian geologist who spent many years in the district, the land was raised above the sea at or shortly after the close of the Eocene period, and ever since has been continuously subjected to decomposition by meteoric agencies, and to sub-aerial and stream erosion, the streams having assumed and retained normal courses outwards from the centre of the mountain mass. To quote Mr. Tyrrell, »After the land was raised well above the level of the sea atmospheric agencies began the decomposition of the rocks, and the breaking apart and liberation of the rock particles one from another, while the rain and the smaller and larger streams cut out the valleys, dissolved parts of the rock, and washed the undissolved particles from the higher to lower levels. The very heavy particles, such as the grains and nuggets of gold, would settle close to the places from which they were derived, while the lighter particles would be carried farther away.

The processes of decomposition and erosion, with transportation and separation of the eroded material, went on continuously from year to year and from age to age until the land had been reduced almost to its present level, and the bottoms of the wide and relatively shallow valleys had been filled with coarse pebbles and cobbles of the harder and more resistant kinds of rock, though chiefly vein quartz, that had been slowly washed down the adjoining hills. Mixed with these larger masses of rock were the smaller but heavier nuggets and grains of gold, which had been washed out of the same hills, but on account of their weight had not been carried away with the rock particles of the same size. The beds of quartzose gravel thus formed are locally known as the »white gravel« or »white quartz wash«.

After these gravel beds were formed the northward-flowing streams were accelerated and given greater cutting power in some way, probably by a tilting of the land from the south northward, consequent on the continued rising of the mountains near the Pacific Coast. These streams therefore cut narrower valleys, with steeper sides, through the »white gravel« and into the underlying rock, leaving terraces of the »white gravel« on one or both sides of the valleys, and reconcentrated into their beds the gold from the gravel which they had cut through and washed away, as well as any gold that may have been in the rock cut through below the older gravel.

[1] Economic Geology, Vol. II, No. 4, P. 344 et seq.

These two sets of gravel deposits have together produced to date about six million fine ounces of gold, and it is not improbable that there are still four million ounces remaining in the placers, making a probable total content for these Klondike placers of ten million fine ounces of gold.

As has been shown above this gold was concentrated by the rills and streams from the whole of the rocky material washed down from the Klondike mountain-mass, and it probably represents a considerable proportion of the gold originally contained or included in the rock.

In reference to the quantity of rock that was so washed down by eroding and transporting agents acting continuously through a long period of time only approximate data are obtainable, but the following statement is believed to represent with a resonable degree of accuracy the conditions as they existed during the erosion period.

As stated above the mean elevation of the land when active denudation began at the close of the Eocene period was 3,500 feet, taking the present sea level as a datum. The mean elevation of the district at present is about 2,600 feet above the same datum, from which it would appear that the thickness of the rock removed from the surface between the end of the Eocene Age and the present time is equal to a thickness of 900 feet over the whole area. Adopting the ordinary time scale of 4,000 years for the removal of one feet of surface, 3,600,000 years would be the time required for the removal of the 900 feet of surface, and such, according to this computation, would be the length of time since the close of the Eocene period. A thickness of 900 feet over an area of 800 square miles would equal a mass of 136 cubic miles or 1,600,000,000,000 tons of rock. This is, therefore, the quantity of rock that was removed by denudation, and from which 10,000,000 ounces of gold was washed and concentrated into the Klondike placers, and it represents an average gold content 0,003 grains or 0,013 cents to the ton of the original rock in place.

It is thus that the Klondike district owes its phenominally rich placers, not to the wearing down of highly mineralized gold-bearing veins or lodes, but rather to the favourable conditions of long and uninterrupted concentration from a great mass of rock that contained only very minute quantities of gold«.

While recently some attention has been directed towards the development and operation of lode mines, the alluvial deposits, which during the past thirteen years have yielded approximately $ 130,000,000., still continue to be the main source of production. The methods of mining include »ground sluicing and shovelling in, hydraulicing and dredging«. For thawing frozen ground an efficient and unique system has been developed. The equipment for this purpose includes a boiler of not exceeding 50 H.P., iron piping, steam hose, and five feet length of steel pipes tipped with very hard steel bored at the end, the hole being a quarter inch in a diameter. This point is driven into the frozen gravel, while the steam from the boiler, maintained at a pressure of from 80 to 100 pounds, is forced through it. The"thawer" is put to many uses, especially in the sinking of shafts, and by its means mining may be continued much later in a season than would be otherwise possible. On the authority of a mining engineer for many years resident in the Klondike district, pay-dirt in solidly frozen ground can be mined from tunnels and drifts, hoisted and sluiced for about $ 3.00 a cubic yard. The dredges in use in the Yukon are all built on the ladder and bucket principle, and since there is an absence of large boulders, gravel when free from frost is very easily moved by this means. The cost of digging has recently been considerably reduced in consequence of the installation of hydroelectric transmission plants. Thirteen dredges were in operation in the Yukon last year; while a recent innovation is the electric elevator, of which three have recently been installed. The elevator is fully equal in performance to a dredge, costs less, and may also be operated in localities where conditions are not favourable to dredging. Since their installation the elevators have proved highly efficient.

Continued mining activity in the Yukon is indicated by the official returns for 1909 which show that 909 entries for placer mining claims, 563 entries for quartz mining claims and 4,385 renewals and relocations were officially recorded during the fiscal year; while sixty-nine leases to dredge for minerals are in force.

Labour in the Yukon is, as might be expected, costly, the ordinary rate for miners being from $ 5.00 per day.

COPPER.

The three copper-producing Provinces of the Dominion are Quebec, Ontario and British Columbia, of which the latter is by far the heaviest contributor. Although copper mining is one of the oldest of the Canadian mineral industries, it occupied a relatively unimportant position until some twelve years ago, when to the considerable production then commencing from the Sudbury district mines in Ontario, was added the output of the copper mines of Western Canada. Since that date the expansion of the industry has been notably rapid.

QUEBEC. Ores of copper are found in numerous localities in the Eastern Townships, and also in the South-Eastern portion of the Province of Quebec. In the Eastern Townships, to which distinctive operations are at present confined, the occurrence is chalcopyrite with some chalcocite and bornite, in pyrite, replacing country rock and forming lenses in pre-Cambrian schistose porphyries and andesites. The individual lenses rarely exceed in width 20 to 30 feet, or in length 200 to 300 feet, having about the same dimensions along the plane of the dip. At depth the metallic contents of these ores average from 25 % to 38 % in sulphur, 1—½ % to 8 % in copper and values, ranging between $ 2.00 and $ 12.00 per ton, in gold and silver. At one property all ore containing over 38 % in sulphur is transported direct for treatment, while that of lower grade is concentrated locally to that percentage, and with the picked ore sent to works at Boston, Mass., U. S. A., where it is used in the manufacture of sulphuric acid. The copper is subsequently recovered from the cinder by smelting. At another mine the ore is utilized in local works in the manufacture of sulphuric acid and chemical fertilizers, and the cinder also smelted locally into a matte in a Herreschoff furnace. These mines represent the oldest established copper undertakings in Canada, having been in operation for between 30 and 40 years, and continuously for over 20 years. They have paid very handsome profits on the capital invested. The mines are opened by shafts, while a method of mining is devised to suit the local requirements. In one of the mines a depth of over 3,000 feet has been attained. Miners are paid from $ 1.50 to $ 1.75 per day.

ONTARIO. Quite the major proportion, considerably over 90 %, of the copper produced in Ontario is at present contributed by the nickel-copper mines of the Sudbury district; important occurrences of copper ores are, however, widely displayed through the district bordering the North shore of Lake Huron, and also in the Parry Sound district. The Sudbury ores occur as pentlandite, chalcopyrite and pyrrhotite in large irregular deposits at the edge of a great body of norite intruding pre-Cambrian sediments and igneous rocks. The mines are worked primarily for their nickel contents, hence the copper production is regulated to a very considerable degree by nickel market requirements. The ore is first smelted to a 35 % matte, which by subsequent bessemerization is raised to about 80 %. This product is then refined by a special process at works in the United States. The average copper and nickel contents of the ore mined and smelted in 1908 was copper, 2.08 %. and nickel, 2.65 %. In 1909, 462,336 tons of ore were smelted, from which 25,845 tons of Bessemer matte was produced, containing 7,873 tons of copper and 13,141 tons of nickel.

BRITISH COLUMBIA. The copper mining industry of BritishColumbia,[1] while relatively still in its infancy, can show a record of progress and achievement comparable with that of any copper producing country in the world. Its inception dates from 1894, when the first shipments of gold-copper ores were made from Rossland. The definition "gold-copper" is here advisedly used; since the gold in the Rossland ores was from the first, and still is, the chief constituent of value. The first shipments, however, contained no less than 5.21 % copper, but this was by no means representative of the average of ore; the conditions at the time requiring that only exceptionally rich selected ore should be marketed. Following the development and operation of mines in the Rossland district, the constructions of railways rendered available the immense copper resources of the Boundary district, forty miles West of Rossland; while at the same time, copper mining began to assume important proportions on Vancouver Island, the mainland coast districts and elsewhere. More recently new areas have been developed or are undergoing development in the islands belonging to the Queen, Charlotte Group, and again still further North in the Portland Canal district, bordering on Alaska.

There are now established in British Columbia no less than seven large smelteries, one of which, that at Grand Forks, is the largest in the British Empire, at which the gold-copper and copper-gold ores are treated.

The haracter of the principal deposits now importantly productive are: In the Boundary district, Mgnetite, chalcopyrite and pyrrhotite in varying proportions, and small quantities of pyrite and hematite, occurring in immense bodies, of the contact metamorphic type, within a series of Palaeozoic sediments, and mainly confined to beds of limestone and tuff. The ores are associated with secondary rock minerals (garnet, hornblende, calcite, quartz, etc.), and occur in fissured zones, replacing the country rock. As a rule the ore bodies have no well defined walls, but gradually give way to country rock.[2] Mr. R. W. Brock, Director of the Geological Survey, who has devoted special study to these and other copper deposits in British Columbia, states that the minerals are not evenly distributed through the ore-bodies, but in the more typical mines

[1] Extract from chapter contributed by the writer to „Report on Mining and Metallurgical Industries of Canada, 1907—8", page 136, Mines Dept., Ottawa, Ont.

[2] Geology and Economic Minerals of Canada, G. A. Young, page 133.

the distribution of the various ore minerals, in bands or masses in which one or more of the minerals largely predominates, gives rise to magnetic ore, and calcareous ore that are mixed in suitable proportions to form a practically self-fluxing ore for smelting. A representative analysis would be the following:

SiO_2	33 %
Fe	13 %
Ca O	17 %
$Al_2 O_3$	8 %
Mg O	3 %

The smelter returns on production made by the largest operating company in 1908 show the average metallic values per ton of ore treated to have been: copper, 1.171 %; gold, 0.0503 oz., and silver, 0.2865 oz. per ton. As will be noted these values are unusually low to admit apparently of profitable extraction; and, as a matter of fact, before it had been demonstrated that a mining industry could be successfully established in the area, the field was condemned as unworkable by many eminent engineers. Success has been achieved, however, as a result of careful and capable management, and of peculiarly advantageous natural conditions, including the great size of the ore bodies, permitting extensive mining operations to be economically conducted; the solidity and firmness of the ground that renders the use of timbers largely unnecessary; the self-fluxing character of the ore; cheap fuel; abundant electric power; plentiful water and timber; dry mines; and an unsurpassed climate. In a large measure the mines are worked by either open pits, known locally as »glory holes«, or by »rock pillars or stopes«. By the former method a tunnel is driven under the ore, and raises provided with chutes made thence to the surface. The raises are filled with ore, and the rock is blasted from around their collars, thus forming funnel-shaped openings growing deeper and wider as operations proceed. Shovelling is practically obviated by maintaining the stopes in the funnels at angles of 45 degrees. When the second method referred to of rock pillars and stopes is employed, a series of two or more parallel drifts are driven under the ore, and therefrom raises, provided at the bottom with steel-lined chutes, are made at intervals of about 30 feet, and carried upward from level to level. The whole width of the ore on each level is stoped, pillars, however, being left to ensure the support of the roof. In one mine the practice is to withdraw all the ore from the stopes directly all the ore above the first level is broken. Subsequently the pillars and roofs are robbed to the limit of safety, and the level abandoned. The ore is crushed at the mines before delivery to the smelters. At the smelters the ore is first reduced to a matte, and finally converted to blister copper, which is moulded into bars ready for shipment. The costs of mining, smelting and marketing are under $ 3.50 per ton of ore.

Miners in the Boundary district are paid at the following rates:

Shift boss (foreman)	$ 5.00	per 8	hours.
Blasters	$ 4.50	,, 8	,,
Machine men, timber men, etc.	$ 4.00	,, 8	,,
Helpers, muckers, etc.	$ 3.50	,, 8	,,
Engineers, blacksmiths, and other skilled artisans	$ 4.40	,, 8	,,
Labourers	$ 3.30	,, 8	,,

The characteristic Rossland ores are chalcopyrite and pyrrhotite with some pyrite and mispickel, occurring in fissure veins without any accompanying replacement of the country rock; in zones of shearing as veinlets replacing the country rock; and in irregular impregnations of the country rock. Mr. R. W. Brock publishes the following table of analyses, which may be regarded as typical of the ores now being mined:

Au oz.	.4 to 1.18
Ag oz.	.3 to 2.318
Cu p. c.	.7 to 3.62
Fe p. c.	15.5 to 22.
$Si O_2$ p. c.	37. to 43.
S. p. c.	6.8 to 10.8
Ca O p. c.	4.2 to 17.6
$Al_2 O_3$ p. c.	14.9 to 15.

The pay ore is commonly localized in shoots of from one foot to, in exceptional cases, 130 feet wide; in length, from 50 to 500 or more feet, and of considerable vertical dimensions. Several of the mines have been developed to great depths, in some cases attaining to 1,500 feet or over.

The costs of mining average about $ 4.00 per ton; but in addition large tonnages are available for stoping, which may be mined and raised at a cost not exceeding $ 2.40 per ton. The ore is smelted at local works, the practice being to produce a low grade copper matte, which after desulphurization in Heberlein pots, is raised in the blast furnace to 42 % copper, the metallurgical losses

An open pit in one of the large nickel mines. Sudbury District.

being exceptionally low. As a result of improved methods and the availability of cheap fuel, smelting costs have been reduced from about $ 10.00 per ton in 1895 to about $ 3.00 or less at the present time.

The relative productive importance of the several copper mining districts of British Columbia is shown in the following table compiled from the more recently published official statements:[1]

[1] For a detailed account on this district see Report on the »Nickel and Copper Deposits of the Sudbury Mining District«, by A. E. Barlow, Geol. Survey, Ottawa, 1904.

District	1906		1907		1908		
Yale (Boundary)	32,226,782	lbs	31,521,550	lbs	40,181,790	lbs	85.0 %
Rossland	4,750,110	,,	5,080,275	,,	5,042,244	,,	10.7 %
Coast & Cassiar	5,431,269	,,	3,757,967	,,	1,997,337	,,	4.2 %
Yale-Kamloops	355,377	,,	36,120	,,	.....	,,	..... %
Nelson	216,034	,,	434,222	,,	53,243	,,	.1 %
Other Districts	10,916	,,	2,586	,,	.....	,,	..... %
	42,990,488	lbs	40,832,720	lbs	47,274,614	lbs	100.00 %

The average assays of the copper ores of the various camps, based upon the copper recovered were as follows:

Boundary .....1.35 %
Coast .....2.87 %
Rossland .....0.834 %.

NICKEL.

The Sudbury district, Ontario,[1] is at present not only the chief source of Canada's but, the world's supply of nickel. Under the heading of »copper«, a brief reference was made to the mode of occurrence of these depoits. This information may now be supplemented by the statement that the deposits, largely consisting of pyrrhotite and chalcopyrite, constitute part of the edge of an eruptive sheet of norite, or gabbro-diorite, that has a length of thirty-six miles, a breadth of sixteen miles, and an estimated thickness of a mile and a quarter. It rests in a synclinal basin on upturned Huronian and Keewatin strata intruded by plutonic rocks. The occurrence has been likened rather aptly to what may be observed to take place when molten slag ocols after pouring

Surface plant at mine in Cobalt District.

into its receiving pot. The central portion of the igneous sheet is overspread by stratified rocks, agglomerates, tuffs, shales and sandstones, while the orebearing norite outcrops as an oval band of from about half a mile to rather over four miles in width. Around the inner margin the rock is micropegmatite, gradually changing to norite, while about the outer margin the ore bodies occur and also in offsets of the eruptive body. These ore bodies are often of remarkable extent, one, for example, measuring at thesurface 150 feet by 200 feet, while

[1] Minister of Mines, Report, British Columbia, 1908.

it has been proved to continue to a depth of at least 400 feet. In another mine, belonging to the second class of deposits formed along offshoots from the main norite mass, the ore body has an average width of from 50 to 90 feet, and has been followed to a depth of a thousand feet. Pyrrhotite predominates in the ores, but the nickel is mainly, if not entirely, contained in the pentlandite. Much of the ore is mined by open cut or quarrying methods, although underground systems are also followed. The ore is first roasted for the elimination of sulphur, and then smelted to a 35 % copper-nickel matte, which by subsequent bessemerization is raised to 80 %. The following analyses of these mattes may be of interest:

	I.	II.	III.	IV	V.	VI.
Nickel	39.96	40.93	31.35	41.18	39.64	48.82
Cobalt	—	—	—	—	—	
Copper	43.96	45.71	48.86	44.87	42.75	25.92
Iron	0.30	0.40	0.81	10.94	1.03	2.94
Sulphur	13.76	—	—	11.82	14.05	22.50
Gold	0.1 to 0.2 oz	—	—	0.30oz	0.75oz	.000 075
Silver	7 oz	—	—	5.10oz	5.30oz	.001 775
Platinum	0.25 oz	—	—	—	0.50oz	0.000 430
Iridium	—	—	—	—	—	0.000 056
Osmium	—	—	—	—	—	0.000.057
Rhodium	—	—	—	—	—	Trace
Palladium	0.25 oz	—	—	—	—	Trace

The final smelter product is sent, in the case of one company, to New Jersey, and in another to Wales to be refined.

Nickel is also recovered in connection with the treatment of the silver-cobalt ores of the Cobalt district, the estimated yield from this source in 1909 being 766 tons.

SILVER.

Among the mineral industries of Canada silver mining from occupying a relatively unimportant place now ranks only second to coal in point of annual output value. This has been brought about within the last few years by the discovery and operation of phenomenally rich silver mines within a small area, probably not exceeding ten square miles, in Northern Ontario; and whereas prior to 1904 British Columbia annually contributed over 90 % of the silver won in the Dominion; this position is now exactly reversed in favour of Ontario.

ONTARIO. The discovery of the Cobalt area, as before stated, was due to railway construction operations in that region; and it is an interesting and remarkable co-incidence that the two most important and at the same time unique mineral occurrences in Canada, namely those of Sudbury and Cobalt, have been discovered under the same fortuitous circumstances. Although the first claims were "located" in August, 1893, no production was made until the following year, and, as a matter of fact, the mines did not become importantly productive, nor was the remarkable richness of the region realized or recognized until the Spring of 1905, notwithstanding that Dr. W. G. Miller, Provincial Geologist of Ontario, exhibited specimens of the ore at a meeting of the Canadian Mining Institute in 1904, and at the same time called attention to the notability of the occurrences. Since 1905, however, very extraordinary progress has been made. In 1906 the increase in output was over 100 %; in 1907 a further increase of 100 % over 1906 was shown; while again in 1909 the silver yield was twice that of 1907. Of the total production to date, valued at $ 35,000,000., nearly one-half that amount represents the sum distributed in profits and dividends. In 1909 twenty-eight mines were productive, and of these fourteen paid dividends amounting during the year to $ 6,150,000.

The Cobalt silver ores occur, in the Cobalt district proper, as native silver associated with smaltite and nicolite, etc., in narrow veins of calcite in Huronian sediments and post-Huronian diabase; and in the Montreal River district near by, as native silver and argentite with hematite and various sulphides in aplite dikes, also cutting Huronian sediments and post-Huronian diabase. The veins commonly occupy nearly vertical fissures of often irregular course, splitting or dividing into a series of stringers confined to a narrow zone. In many cases the veins are of considerable horizontal extent, and have been traced for distances of over a thousand feet. Much of the ore produced is astonishingly »high-grade«, carrying in some veins as high as four and five thousands ounces of silver to the ton. Until within a year or so ago any ore below 50 oz. silver content was esteemed valuelsess as being too »low-grade» to repay shipment. Since, then, however, the

low grade ore has been subjected to concentration, there being now nine mills (maximum daily output, 850 tons) in operation in the district, while others are in course of building. The concentration ratio in 1909 were 39 to 1 as compared with a ratio of 45 to 1 in 1908. Cyanidation is also employed in some instances as an auxiliary process. The ore and concentrates are consigned for treatment to reduction works in Canada, the United States, Germany, and England. The bulk of the high grade product is, however, smelted in Canada. In general, the foreign smelters

A calcite vein in the Cobalt District, in which the silver commenly occurs.

pay for the silver contents (95 %) alone, while arsenic, in excess of 5 % is penalized. The treatment charges vary at different works, and according to the grade and character of the ore shipped, but the following schedule of a works in Newark, N. J., U.S.A., may be quoted as affording some general idea: 45 c for each % of arsenic in excess of 6 %, and 6 c for each % of insoluble in excess of iron; Ores over 1000 ounces to 1500 ounces, pay for 93—½ % of the silver contents and a smelting charge of $ 4.00 per ton of ore, with penalties as above; Ores above 1500 ounces to 2000 ounces pay for 93—½ % of the silver contents, and a smelting charge of $ 20.00 per ton of ore, with penalties as above; Ores over 2000 ounces silver per ton, pay for 93—½ % of the silver contents, and a smelting charge of $ 19.00 per ton of ore, with penalties as above.

The Canadian smelters allow 75 % of the value of the silver contents on ore under 200 oz.; 93 % on 100 oz. ore; 94—½ % on 2000 oz. ore; and 94—¾ % on 3000 oz. ore. They also pay for the cobalt content in excess of 6 %.

BRITISH COLUMBIA. About 75 % of the silver won in British Columbia is derived from the mining of the argentiferous galena ores of the Slocan and Fort Steele deposits, described elsewhere in this paper, while the remainder is recovered from the copper-gold and gold-copper ores of, respectively, the Boundary and Rossland districts. In the Slocan districts the proportion of silver to lead in the ores averages from 1 to 1.5 oz. of silver per unit of lead. In exceptional instances, however, this ratio is as high as 10 to 1.

LEAD.

Ores of lead occur in the Yukon Territory and in the Provinces of Quebec, Ontario and British Columbia, but production since 1904 has been made from the latter Province exclusively; at no time, however, has the output of lead from either Quebec or Ontario been considerable. The main occurrences in South-Eastern British Columbia, whence production is at present derived, are argentiferous galena with zinc-blende and pyrite as associate minerals, forming irregular lenses in a fissured zone with pre-Cambrian quartzite; or argentiferous galena in association with argentiferous tetrahedrite, native silver and gold, argentite, zinc blende, copper and iron pyrites, in a gangue of quartz, siderite and calcite, in veins cutting sediments; or lastly, as galena, zinc blende, pyrite and pyrrhotite, replacing crystalline limestone along a zone of shearing. The first mentioned describes the occurrence at Moyie, in the East Kootenay division, the largest lead deposit yet discovered in Canada, and the second largest, it is believed, in the North American Continent. The ore bodies lie in a nearly vertical fissure zone, consisting of two main, nearly parallel fissures connected by cross veins. The ore bodies are found along the courses of the main and cross veins, especially at the junctions, and are of very considerable size. Thus the main veins average about six feet in width, while the cross fissures, and the points of their junction with the main fissures, are from thirty to fifty or more feet wide. In height some of the lense-like bodies attain to 150 feet, while in one instance a drift was continued for a thousand feet in solid ore. Other lead mining districts are those of the Lardeau, Ainsworth, Slocan and Nelson in the West Kootenay division, and the Windermere and Fort Steele districts in the East Kootenay. Some production has also been maintained from mines in the Boundary district.

In the Slocan district the deposits are almost exclusively confined to fissure veins found in the slates, the pay ore being generally localized in chutes, and are frequently concentrated around inclusions of carbonaceous country rock, or along and occasionally in the wall-rock. The deposits are divisible into two series, the dry ore or silicious veins, adjacent to and occasionally penetrating the granites, and the lead ore veins in the slates. There is no clearly marked or definite order of mineral succession in these veins, but galena occurs in the outcrops of nearly all the pay veins, and is also found in quantity at depth. It appears to favour the hanging wall of the veins, and is generally more abundant in the first 300 feet than at greater depth. In the pay veins silver ores are associated with galena, some copper mineral and zinc blende, in a highly quartzose gangue.

The Ainsworth deposits occur in limestones; in Windermere district carbonate of lead occurs, as also near Salmo, in the Nelson district. In the Lardeau district the ore occurs in veins cutting carbonaceous slate and schist.

Lead mining has been conducted in British Columbia since 1887, a maximum production being reached in 1904, since when, conditions — in consequence of restrictive duties imposed on Canadian lead entering the United States, at one time the principal market — have been less favourable. Subsequently the Dominion Government came to the assistance of the industry by subsidizing the production of lead in ores. This, together with an improvement in methods and reduction of costs of freight and treatment, has had a stimulating effect, although the heavy output of 1904—5 has not since been equalled.

The majority of the lead mines being situated on precipitious slopes, entry is usually made by adit tunnels. Much of the ore is concentrated, while both concentrates and lump ore are smelted in local smelteries. Freight and treatment costs on Slocan (wet) ores are approximately $ 10.00 per ton for 70 % lead ore; while the maximum charge is $ 13.00 on a basis of 10 c per unit of lead below 70 %. Ores containing an excess of zinc over 10 % are penalized. 90 % of the lead in the ore is paid for.

Milling costs range from 40 c to 70 c per ton; and of mining from $ 2.00 to $ 2.50 per ton. Miners are paid from $ 3.25 to $ 3.50 per day of eight hours; shovellers, $ 3.00; blacksmiths, $ 4.00; mill-foremen, $ 4.50; jig-men and table-men, $ 3.50; engineers, $ 3.75; helpers, $ 3.00 The high grade character of the argentiferous galenas of the Slocan district is signified by the statement that the average production represents, silver, 90 oz. per ton, lead, 40 %, and zinc, 9.8 %. Much of the lead produced in British Columbia is refined electrolytically at Trail. This refinery has a capacity, that, however, is now being increased, of from about 80 tons of refined lead (99.99 pure) per day. A considerable proportion of the refined product is consumed in Canada, where it is used in the manufacture of white lead, the balance being marketed in the Orient, and elsewhere. Lead pipe is also manufactured at Trail.

The relative productivity of the respective districts is shown in the following table:[1]

Fort Steele	M.D. produced	30,204,788	lbs. Lead	=	69.90 %	of total.
Slocan	,,	6,572,268	,, ,,	=	15.20 %	,, ,,
Ainsworth	,,	4,790,216	,, ,,	=	11.10 %	,, ,,
Trout Lake	,,	873,860	,, ,,	=	2.10 %	,, ,,
Nelson	,,	345,424	,, ,,	=	0.80 %	,, ,,
All others	,,	409,177	,, ,,	=	0.90 %	,, ,,
		43,195,733			100.00	

ZINC.

Heretofore the production of zinc in Canada has been relatively inconsiderable. This is in part due to unfavourable treatment and market conditions. Until 1905 concentrates were marketed in the United States, and, as »calamine« were admitted free of duty. In the following year, however, it was proclaimed that »calamine« as specified in the tariff had reference only to the hydrous silicate of zinc, and that sulphide and carbonate ores were subject to a duty charge of 20 %, ad *valorem* in consequence of this decision production for the American market ceased to be profitable, and in 1906 practically no output was made[2]. Since then, however, an endeavour

Open cut at iron mine, Moose Mountain, Ontario.

has been made to revivify the industry, the future prospects of which are largely dependent on the cheap local production of spelter. To this end electro-metallurgical experiments have been conducted for some time past at Nelson, British Columbia, and recently a grant was made by the Dominion Government for the furtherance of this aim. Zinc is found in three Provinces, but has only been mined to any extent in British Columbia, where it usually occurs with the argentiferous galenas of West and East Kootenay. In the Slocan district the average zinc tenour of the ores is about 9.8 %; in the Ainsworth district probably 15 %; while some of the East Kootenay ores will vary from 4 % to 20 %. At a number of the silver-lead mines the concentrating mills have been remodelled for zinc recovery, while the ores are also enriched by magnetic separation to the market requirement of 45 % to 50 % metal.

[1] Report, Minister of Mines, British Columbia, 1908.

[2] It is stated that the United States Treasury Board has since ruled that zinc ores may be admitted into that country free of duty. Minister of Mines Report, B. C., 1908, page 24.

Iron mining is at present of industrial importance in the Provinces of Nova Scotia, Quebec and Ontario only. A considerable expansion of the industry may, however, be expected in the near future, since the development and utilization of important resources both in the Province of New Brunswick and in the Province of British Columbia are now in progress.

NOVA SCOTIA — Numerous deposits of iron ore occur in Nova Scotia, but mining to any extent is only carried on in the Nictaux, Torbrook and Londonderry districts. At the former the ore occurs, sometimes five to ten feet wide, in rocks of upper Silurian or lower Devonian age; while at Londonderry a zone of fissuring, often a hundred or more feet wide, is occupied by a complicated system of veins of Ankerite, Siderite, etc., Magnetite, Hematite and Limonite being also frequently abundant. An analysis, said to be representative, shows: metallic iron, 51 %; silica, 13.50 % phosphorus, 1.15 %; sulphur, 0.02 %. The production of iron from Nova Scotia in 1909 was 12,000 tons only.

NEW BRUNSWICK AND QUEBEC. — In New Brunswick a notable discovery of hematite is being developed near Bathurst. The ore body, which outcrops over a length of nearly two miles, shows a width, where exposed, of from 30 to 40 feet. In Quebec bog iron ores are at present alone utilized. It is estimated, however, that on the north shore of the St. Lawrence are deposited some twenty-five million tons of high grade titaniferous magnetite iron sands, which, if suitable processes be devised for briquetting the sands and eliminating the titanim, might be turned to very profitable account.

The distribution of iron ores in Ontario is very wide, there being no less than fifty-one localities in which deposits are known to occur. Heretofore hematite has been chiefly mined, but since the development of an important magnetite deposit near Sudbury, the production of magnetite has shown a considerable increase. The principal deposits now being mined are the magnetites of the Moose Mountain Range near Sudbury; the hematite-limonite deposits of the Helen formation, in the Michipicoten district; and the magnetite deposits of Eastern Ontario[1].

Another important occurrence, the magnetite deposits at Atikokan, should also be classed among those producing iron, since operations have been only temporarily suspended.

The Helen mine formation[2] has a total length of one and three-quarter miles, and is over nine hundred feet wide, consisting chiefly of ferriginous and banded cherts and cherty siderites containing the iron ores proper, hematite and limonite, and also pyrite. The total thickness of the deposit is 288 feet. The first grade ore, a hard compact red hematite, yields 60 % and over metallic iron; the second, porous but hard brown limonite, 57 % to 58 % iron; and the third, soft brown limonite, 53 % to 54 % iron. An analysis of the ore, representative of the stock piles at blast furnaces, gave the following returns:

Fe	57.10
SiO_2	5.27
Al_2O_3	1.04
P	1.128
Mn	0.038
CaO	0.20
MgO	0.10
S	0.053
Moisture	3.44

In the Moose Mountain formation two deposits have been found, one of which is approximately 500 feet long and 150 feet wide, and the other, consisting of »lean« ore, has been traced for over two miles, and is 40 feet wide. An analysis of the ore from the first mentioned deposits is:

Fe	55.50
SiO_2	13.29
Al_2O_3	1.21
P	0.10
Mn	0.02
CaO	3.60
MgO	3.15
S	0.011

[1] A. B. Willmott, »The Iron Ores of Ontario«, Journal of Canadian Mining Institute, Vol. XI page 106.

[2] A. P. Coleman and A. B. Willmott, »The Michigan Iron Region«, Ontario Bureau of Mines Report. Vol. II, 1902, page 152 et seg.

The Eastern Ontario[1] "shipping" ores yield analysis from 48% to 55% metallic iron, with phosphorous, 0.019 % to 0.022 %, and sulphur, 0.04 % to 0.06 %.

Recently much attention has been devoted by the Ontario Government Bureau of Mines to the problem of the profitable magnetic concentration of ores occurring in considerable quantity in the Province, the character of which, however, renders them unsuitable for utilization without special treatment for the elimination of deleterious mineral associations. Results of experiments in this direction are published in a Report made by Mr. G. C. Mackenzie, a member of the staff of the Ontario Bureau of Mines in 1908.

BRITISH COLUMBIA. — Large bodies of iron ore, both hematite and magnetite, occur in British Columbia, the principal deposit at all developed in the Interior region, being that at Kitchener, some twenty miles East of Kootenay Lake. The ores here, chiefly hematite, are very pure, occurring in deposits of from 5 to 20 feet wide parallel to one another, and outcrop at intervals for several miles. Other large deposits of magnetite are found at several localities on the West and North-West Coast of Vancouver Island; while some production of iron ore has been made from Texada Island, where deposits, either lense-shaped masses, or long vein-like bodies, usually occur along the contact of limestone with granite or porphyrites. The ore is a coarse, crystalline, magnetite, the ore marketed analysising Fe 64 % to 68 %; S 0.05 to 0.29 %; P trace to 0.2%. Arrangements are now being made, it is reported, to establish at Vancouver iron and steel works for the utilization of coast ores, which heretofore have been marketed in the United States.

Labour. — In Nova Scotia, the average pay of miners working in the iron mines is $ 1.62 for nine hours; in Ontario, miners, wages range from $ 2.00 to $ 3.50 per day of ten hours.

IRON AND STEEL INDUSTRIES.

The iron and steel industries of the Dominion are yet, to use a trite phrase, "in their infancy", yet the standard practice is very high and the works as established are most efficiently equipped. The most important undertaking in Nova Scotia, that of the Dominion Iron & Steel Company, was established at Sydney less than ten years ago. The plant now includes four 250-ton blast furnaces, ten 50-ton open hearth furnaces, a blooming mill and pit furnaces, rail rod mills of the continuous type and of large capacity, and a continuous billet mill. A second important undertaking is that of the Nova Scotia Steel and Coal Company, with works at North Sydney and Trenton; at Trenton, the plant is equipped for the production of steel billets, bars, plates, and car axles. The ore utilized in both works is obtained from extensive deposits of high quality hematite at Wabana, Newfoundland, averaging over 55 % metallic iron, with a phosphorous content of 1.01 % and sulphur, a trace only. The average rate of wages paid is $ 1.90 per day to men employed at the steel works.

The third and oldest established works are those at Londonderry, producing high grade foundry iron from native ores. In Ontario the largest individual plant is that operated by the Algoma Steel Company, Limited, at Sault Ste. Marie. The equipment here includes two acid bessemer converters, two basic open-hearth furnaces and a rail mill having a capacity of 225,000 tons annually.

Other iron and steel works in the Province are those at Hamilton, Midland, Deseronto, Port Arthur and Welland. The manufacture of ferro-silicon is also undertaken at Welland, where four electric furnaces of the Heroult type, each of 1,000 to 1,500 h. p., are established. The production is from five to eight tons of ferro-silicon daily, an analysis of which is:

Silicon	55.000 %
Iron	43.000 %
Carbon	0.160 %
Sulphur	0.040 %
Phosphorous	0.036 %

For some years past the Dominion Government has assisted the iron and steel industries of the country by a system of bonusing the production of pig iron, manufactured iron, and steel. During the present year (1910) bounties will be paid as follows:

a) In respect of pig iron manufactured from ore, on the proportion from Canadian ore produced during the Calendar year, ninety cents per ton;
b) In respect of pig iron manufactured from ore, on the proportion from foreign ore produced during the Calendar year, forty cents per ton;
c) On puddled iron bars, sixty cents per ton;

[1] Report, Ontario Bureau of Mines, Vol. XVII, (1908) page 190 et seg.

d) On wire rods not over three-eighths of an inch in diameter, manufactured from steel produced in Canada from ingredients of which not less then 50 % of the weight thereof consists of pig iron made in Canada and sold to Canadian consumers, six dollars per ton;

f) In respect of steel manufactured from ingredients of which not less than 50 % of the weight thereof consists of pig iron made in Canada, sixty cents per ton.

Bounties on the production of iron and steel by the electro-thermic process are also offered, as follows:

a) On pig iron manufactured from Canadian ore by the process of electric smelting: —

1910 $ 2.10 per ton.
1911 $ 1.70 ,, ,,
1912 $ 0.90 ,, ,,

b) On steel manufactured by electric process direct from Canadian ore, and on steel manufactured by electric process from pig iron smelted in Canada by electricity from Canadian ore: —

1910 $ 1.65 per ton.
1911 $ 1.05 ,, ,,
1912 $ 0.65 ,, ,,

The increase in the production of pig iron in 1909 as compared with the returns for the corresponding twelve months in 1908 was 20 %; while an equally large increase was shown in steel production. By Provinces, the pig iron production was as follows:

Province	tons	1909. value	per ton.
		$	$
Nova Scotia	345,380	3,453,800	10.00
Quebec	4,770	125,623	26.34
Ontario	407,012	6,002,441	14.75
total	757,162	9,581,864	12.65

A classification of the product indicates that 222,931 tons represented Bessemer; 400,921 tons, basic, and 116,307, foundry and miscellaneous. The amount of Canadian ore used during 1909 was 231,994 tons, imported ore, 1,234,990 tons, mill cinder, etc., 25,508 tons. In connection with blast furnace operations there were employed 1,486 men and $ 879,426 were paid in wages. In all, eleven furnaces were in blast. Steel production returns during the year is detailed as having been:

	tons	value
		$
Ingots-Open hearth (basic)	535,988	9,372,615
Bessemer (acid)	203,715	3,829,012
Castings-Open hearth	14,013	1,043,370
Other steels	1,003	114,713
total	754,719	14,359,710

Eight steel plates were in operation, employing 2,073 men, whose wages aggregated $ 1,284,940. The Government bounties paid in 1909 amounted to $ 640,108 on pig iron; $ 766,470 on steel ingots and $ 488,432 on steel wire rods, or a total not far short of two million dollars.

ASBESTOS.

Asbestos, of the crysotile variety, occurs in several localities in the Province of Quebec, but production representing Canada's total asbestos output is exclusively derived from mines operating in three centres of a relatively small area in the Eastern Townships. These centres are known as, respectively, the Thetford-Black Lake District; the Danville district, 45 miles to the South-West; and the East Broughton district, 25 miles to the North-West. The mineral is found in gash veins in the serpentine rocks that form part of a belt or series parallelling the Atlantic Coast from Georgia to Newfoundland. In the Province of Quebec the belts are nearly continuous from the international boundary line to Thetford, a distance of 150 miles. The serpentine with which the asbestos is associated is derived from the alteration of peridotites, and is principally of middle Palaeozoic age. The veins rarely exceed three inches in width or two hundred feet in length, while the majority are less than three-quarters of an inch wide and but a few feet in length. They

[1] J. A. Dresser, Journal of Canadian Mining Inst. Vol. XII, 1909, page 168.

are, however, very numerous, and in one locality as many as seventy veins have been found within a radius of only two feet. The larger veins (those belonging to the horizontal series being occasionally over two inches wide and from 100 to 200 feet in length) occur in the joint planes of the original rock; others in fractures produced by regional metamorphism, and again in crevises. Mr. J. A. Dresser, of the Geological Survey of Canada, remarking on the distribution of the asbestos-bearing portions of the serpentine belt, expresses the opinion that while the productive areas are relatively small, yet they nevertheless form asbestos deposits that are practically inexhaustible. By far the greater proportion of what is known as No. 1 or long fibred asbestos is the product of three mines in the Thetford district; while the output of the Black Lake, Danville and East Broughton mines is milled, the veins in these areas producing a fine, short fibre that is eminently suitable to the purpose. Mining is conducted by open-cuts or quarrying methods,

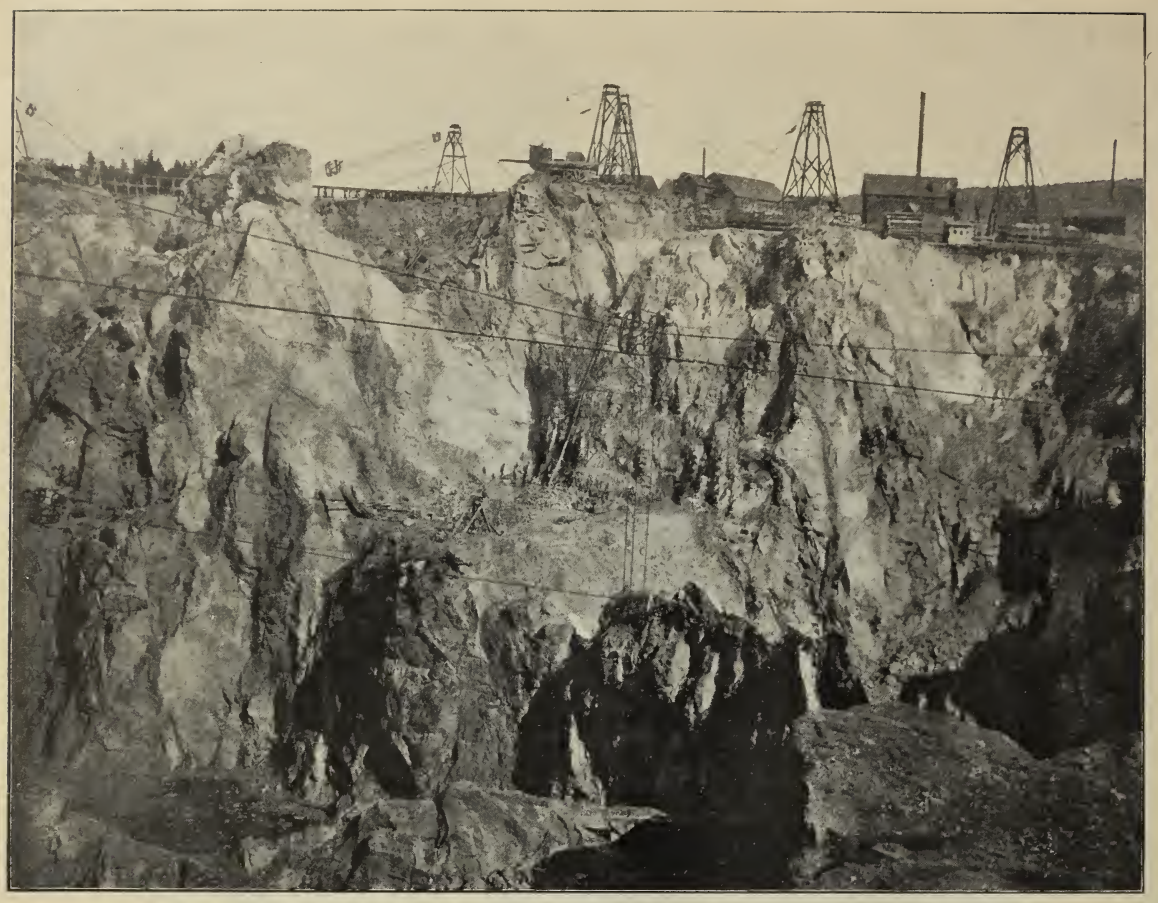
The Thetford Asbestos District. The Photograph shows the developement of large veins of asbestos.

although at one of the larger mines underground operations have also been successfully initiated. The broken rock is picked over in the pits, the milling material being sorted out by hand, hoisted by means of boom and cable derricks, and conveyed to the mills, where it is subjected to a special process of crushing and fiberizing. The mechanical treatment of the lower grade products was not introduced before the year 1892, prior to which time only "crude" was produced. Its introduction consequently revolutionized the industry, which has been further stimulated in recent years by the enormously increased demand, and the many new uses to which asbestos is applied. As an indication of recent progress it may be stated that in 1909 no less than eigth or ten new mills were either erected or in course of construction, while also large works for the local manufacture of asbestos, including slates, board, paper, cloth, etc., were established near Montreal.

The present price of asbestos is approximately as follows:

	$	$
No. 1 Crude	250 to	300 per ton
No. 2 Crude	120 ,,	150 ,, ,,
No. 1 Fibre	45 ,,	70 ,, ,,
No. 2 and 3 Fibre.	18 ,,	40 ,, ,,

Labour is comparatively cheap. Foremen are paid at the rate of $ 2.00 for a 10—½ hour day; drillmen, $ 1.90 to $ 2.00; helpers and labourers, $ 1.75, and boys 60 t to $ 1.00.



A quarry at an Asbestos mine, Thetford District, Quebec.

CORUNDUM.

Although relatively regarded the corundum industry is a minor one, yet the fact that Canada supplies the major part of the world's consumption, is sufficient to justify some remark on the occurrence of the mineral in this country. Corundum was discovered some fourteen years ago in Ontario, and since then corundiferous rocks have been found to occur at intervals along a belt extending some seventy-five miles through three countries in Ontario, those of Haliburton Hastings and Renfrew, into the Province of Quebec. The Canadian deposits are noteworthy not only by reason of the great area covered by the corundum-bearing rocks, but also as regards the relative richness of individual occurrences, as well as on account of the purity and unaltered character of the material recovered. The mineral, in general, is associated with various types of alkali syenites, nepheline syenites, corundum syenites, anorthosites etc., its frequent occurrence, and, all times the abundance of corundum in the nepheline syenites being of special interest to geologists, since, so far as is known, this is unique. In age the corundum rocks doubtless belong to the Archaean, although they are intrusive into the granite and diorite gneisses, classified generally as Laurentian.

Mining is carried on by means of open-cuts, and the material after hand sorting is then concentrated to a 50 % to a 60 % product, and by further treatment, including magnetic separation and re-concentration, is raised to marketable grades of purity and fineness.

OTHER MINERALS.

Space limitations preclude any more than the merest passing reference to those several Canadian mining industries that, though at present of but secondary importance, are likely in the near future to come into greater prominence. These industries among others include antimony, arsenic, cobalt, chromite, graphite, gypsum, mica, natural gas, petroleum and platinum production.

Antimony occurs in nearly vertical veins of auriferous stibnite, in the gold-bearing series in Hants County, Nova Scotia. Some of these veins have been traced for at least 1,200 feet on the surface, and have been developed vertically to a depth of 500 feet; the width varying from a few inches to as much as seven feet. Values as high as 60 % antimony and over 2—½ oz. gold have been obtained; but an average sampling would probably yield about 15 % antimony and from an ounce and a half to two ounces gold. The mines have been intermittently worked since 1880. Native antimony and stibnite also occurs in the Province of New Brunswick, in British Columbia, and in the Yukon Territory.

A few years ago the only arsenic works in North America were these in North Hastings, Ontario. At present three concerns in Canada are engaged in making white arsenic, the production in 1909 being 2,258,187 pounds; while in addition 1,074,511 pounds of arsenic were exported in the form of speiss. The arsenic is derived almost entirely as a by-product from the treatment of the cobalt-nickel arsenide ores of the Cobalt district, although a percentage is obtained from mispickel ores mined in Eastern Ontario.

As a result, also, of the operation of the Cobalt district mines, the Canadian production of cobalt oxide is far in excess of the world's consumption, and in consequence since 1907 the price has declined from $ 2.50 per pound to between 80 cts. and 85 cts. per pound.

Chromic iron occurs very generally and occasionally in large bodies in the peridotite and the serpentine rocks in the Eastern Townships of the Province of Quebec, but production is at present confined to one county. The Canadian production represents about 10 % of the world's consumption. The crude ore containing 40 % and over chromic oxide is directly marketed, but if below that grade is concentrated. The first class crude ores or concentrates rarely exceed 55 % chromite.

Extensive deposits of graphite are found in numerous localities in the Provinces of Quebec and Ontario, within the region occupied by rocks belonging to what is termed the Hastings-Grenville series. There are three general modes of occurrence, the first, and, economically considered, the most important, when the mineral is found in small scaley particles disseminated through bands or beds (varying in thickness from one to thirty feet or more), of gneiss, quartzite, etc.; a second class of deposit in which the graphite occurs in a fibrous or laminated form in narrow veins in igneous rocks; and a third class, in which the graphite is contained in numerous small vein-like or lenticular masses in crystalline limestone. In the first class of deposit the percentage of minerals in the graphite-bearing rocks is frequently from ten to fifteen, while in some beds thirty to forty per cent. graphite is encountered. The ore is mined, as a rule, by quarrying methods, a marketable product being obtained by concentration. Both the dry and wet processes have been employed, but the latter appears to have afforded the more satisfactory results.

Gypsum has a wide geological and geographical distribution in Canada. The largest production is, however, now obtained from beds, associated with the lower carboniferous limestones, in New Brunswick and Nova Scotia. In some localities in these Provinces the deposits are very extensive, forming beds 200 feet or more in thickness. Other large deposits, in the salt-bearing Salina formation of upper Silurian age, in Ontario; and in formations of Devonian age, in Manitoba, are also worked. The material in the crude state is for the most part marketed in the United States. The costs of production in Nova Scotia is reported to be forty-two cents per ton.

Workable deposits of mica in the three varieties, muscovite, phlogopite, and biotite, occur in sections of Eastern Ontario and the neighbouring districts in Quebec, and especially in the Ottawa region. The muscovite variety occurs entirely in pegmatite dikes, either in isolated crystals, sometimes of unusually large dimensions, or in accumulations near the walls of the dikes. The phlogopite variety is, however, chiefly produced. It is commonly accompanied by apatite and lies in vein-like bodies parallelling the plane of foliation of the surrounding gneissic rocks, or cutting these planes traversely. A large market for the product is the United States, notwithstanding the heavy customs impost of 6 c per pound on crude and 12 c per pound on cut mica, together with 20% *ad valorem*. Mica also occurs in British Columbia, but production heretofore has been of a merely tentative character. It is interesting, however, to note that Canada is one of the three countries of the world in which mica deposits of economic importance are found.

Natural gas is the basis of important industries in the province of Ontario, production, which is steadily increasing, having been valued at $ 1,188,000. in 1909. The industry is confined to a region in South-Western Ontario, the gas horizons being in the Clinton, Medina, and Trenton formations. One group of fourteen wells drilled to depths of about 3,000 feet yield regularly about 30,000,000 cubic feet of gas per day, while some individual wells have yielded as high as

1,000,000 cubic feet of gas per day. In the Province of Alberta natural gas has been found along the Athabaska River in the North, and near Medicine Hat, on the main line of the Canadian Pacific Railway, in the South. In the latter locality gas was encountered in an upper horizon at a depth of 700 feet, but the majority of the wells have been drilled to a depth of about a thousand feet. The gas is found in sandstone beds intercalated with Niobrara shales. From one well the yield is about 1,500,00 cubic feet per day, the gas when tubed and closed in registered a rock pressure of nearly 600 lbs.

The chief Canadian oil fields at present productive are those of South-Western Ontario, in the margin between Lake Huron and Lake Erie. This region is underlain by rocks of Devonian age, the petroleum being largely obtained from horizons in the corniferous at depths varying from 450 feet to over a thousand feet.

The actual mining of platinum is restricted to one district, that of the Tulameen River in British Columbia, where the metal is won from alluvial deposits by ordinary placer mining methods. In Ontario, a small quantity of platinum is annually recovered in connection with the mining and treatment of the Sudbury nickel-copper ores, with which is associated, to, however a very minor degree, the platinum mineral sperrylite.

Among other industries in which great progress is now being made, the manufacture of Portland cement is worthy of special mention. In 1909, production represented an increase of 17%; while the present rapid industrial development of Canada is indirectly indicated by the fact that the sales during that year of this material, so largely used for structural purposes, represented an increase of 50% over the corresponding period of 1908. This is also evidenced in the considerable increased production of structural material and clay products in general.

UNDEVELOPED MINERAL RESOURCES.

In approaching this subject it is merely proposed to broadly generalize on the basis of ascertained facts, or rather to draw deductions from facts obtainable from official sources. This restriction, however, necessarily limits consideration of the question to that of the undeveloped resources of those areas in Canada — a relatively small portion of the whole — officially investigated.

Referring first to fuel reserves, an approximate idea of the available tonnage of easily mineable coal in seams over four feet (1.2 meters) in thickness in accessible areas is afforded in the following table, kindly prepared for the writer by Mr. D. B. Dowling, of the Geological Survey of Canada.

Estimate of Readily Available Coal. (In millions of tons of 2000 lbs.)

Area	Sq. Miles area	Anthracite	Bituminous	Lignite.
British Columbia	1.123	20	38.642	314
Yukon	400	9	32	850
Mackenzie	200	—	—	500
Alberta	19,582	400	44,530	60,002
Saskatchewan	7,500	—	—	20,000
Manitoba	48	—	—	230
Ontario	10	—	—	25
New Brunswick	113	—	155	—
Nova Scotia	992	—	6,250	—
	29,967	429	89,609	82,021

Total, 172,059 million tons.

This is probably a very conservative estimate, since according to another authority, Mr. James McEvoy the Coal reserves of the Crow's Nest Pass area, in British Columbia, alone represent 22,595,000,000 tons; while in the Lethbridge area coal has been exposed over an area sixty miles long by a mile wide; and throughout the West and North-West new coal fields are being constantly discovered. In Nova Scotia the Pictou measures are the thickest in the World, while the Sydney field, it is estimated, contains 1,000,000,000 tons of coal. A practically undeveloped field is that of New Brunswick, where there are very extensive coal areas, which in due course should become importantly productive. The coal here occurs near the surface in comparatively thin seams, the supply, it is computed, representing 150,000,000 tons of coal. The coal reserves of Manitoba likewise have not been attacked. While no coal is found in the Central Provinces, Ontario is known to possess workable peat beds spread over an area

of 10,450 square miles. It is merely a question of time before the problem of the utilization of these resources shall have been solved.

As already shown, relatively little has as yet been attempted in the direction of the development of an iron industry in Canada. In the Province of Nova Scotia, iron ore is very widely distributed. While it is questionable whether a local industry is capable of ever competing very extensively with the American and Ontario producers in their own field[1] yet there is a fair possibility of maintaining a production sufficient to satisfy future Eastern Canadian market requirements. The authority cited adds: "Every ton of iron or steel that can be made from native ores at a cost to meet the existing conditions of trade can be sold. Whether or not iron and steel can be made from native ores for export, there certaintly will be room in the near future for all the metal that can be produced for manufacturing purposes in Eastern Canada, and especially in the Provinces of Nova Scotia and New Brunswick". In the latter Province iron occurrences are also common over a wide area; and to emphasise this statement it is only necessary to refer to one deposit, that at Bathurst, the discovery and development of which is of very recent date, where, according to the measurement of a well known consulting engineer[2], the available ore carrying over 50% metallic iron in the three principal ore-bearing areas aggregates twenty million tons. Again, farther north, Dr. A. P. Low, Deputy Minister of Mines of the Federal Department, has reported the occurrence of enormous deposits of high grade iron ore in Labrador; while in the Province of Quebec, much iron ore, including a vast quantity of magnetic sands, is available for utilization. Possibly, however, the most promising field with regard to immediate possibilities, is that of Ontario. Even the immense resources of the Lake Superior iron ranges in the United States' territory are not inexhaustible, and on the basis of present production, depletion, it is estimated, is only a matter of fifty years. Already indications of this are manifested in the lower standard of the iron produced. Hence attention may be the sooner directed to the development of Canadian resources. Meanwhile, it may be pointed out that the rock formations in Northern Ontario are identical with those found throughout the iron ranges of Michigan, Wisconsin and Minnesota, and they also contain the iron series in many cases identical with those associated with the ore bodies of the American ranges. Thus, Mr. G. C. Mackenzie[3] states that »banded jaspers, magnetites and hematites occur for many hundreds of miles throughout Northern Ontario, and when thoroughly and intelligently prospected will, no doubt, afford many valuable ore bodies. American ironmasters have spent more money in the exploration of one range alone than has been expended in exploring the whole of Northern Ontario«.

Electric smelting, the costs of which will, doubtless ere long, be reduced to a point where pig iron by this process may be produced in successful competition with blast-furnace products, promises meanwhile to become an important contributory factor in the utilization of Ontario iron resources.

In respect of the British Columbia[4] iron deposits, now practically undeveloped, it is important to realize that these are the only known occurrences of iron ore in quantity on the North Pacific Coast, and very little, if any, pig iron is produced in the United States, West of the Rocky Mountains. Consequently a British Columbia industry would have, in addition to a local market, markets in the Western United States, as well as possibly elsewhere. Some years ago the writer in an article[5] on »The Iron Ores of British Columbia«, wrote: »It is not too much to say that British Columbia possesses enormous potential resources in her iron deposits, but these resources must wait on the commercial development of those industries that stimulate a demand for iron. Sooner or later the political reasons which led to the construction of United States battle-ships on the Pacific Coast, for which, British Columbia iron was partially utilized, will give place to commercial reasons connected with the development of trade on the Pacific necessitating the building of a large mercantile marine.

Sooner or later manufacturing industries with their constant demand for the iron which is their base will be brought into being to supply the ever increasing market of the Orient. When these things happen, British Columbia with its abundant coal and lumber in direct connection with its iron, must become the seat of a great iron industry«. Already these developments are being witnessed. Within the next year or two iron and steel works are likely to be established on the British Pacific Coast, and a beginning will have been made in the exploitation of those resources that have been allowed for so long to remain dormant.

---

[1] J. E. Woodman, Report on the Iron Ore Deposits of Nova Scotia, Mines Branch, Dept. of Mines, 1909.

[2] Mr. John E. Hardman, E. M., Montreal, Que.

[3] Report Bureau of Mines, Ont., Vol. XII, page 202.

[4] Minister of Mines Report, B. C., 1902, page 201.

[5] Engineering Magazine, Vol. XX, page 407.

With regard to Canada's undeveloped nickel resources, it is only necessary to remark that the present developed territory, constituting as it does the chief source of the world's supply of this metal, is but a portion of the area in Northern Ontario in which nickel is known to occur, and that neither the middle nor the Northern nickel ranges have yet been exploited. Again, important bodies of similar sulphide material, though of somewhat lower grade as compared with the Sudbury ores, are found at St. Stephen, New Brunswick; while other occurrences, though not perhaps at present of economical importance, are reported from British Columbia and the Province of Quebec. There can be no doubt, however, that both as regards developed and undeveloped nickel resources, Canada's position is unrivalled.

It is manifestly less easy to compute undeveloped resources of the precious metals. An old saying has it that »gold is where you fin dit«. In Canada gold has been discovered in practically every Province and territory of the Dominion. The great extent covered by the rocks of the gold-bearing series in Nova Scotia promises well for further discoveries in that area. In the Province of Quebec rich finds have but lately been made in a district long ago believed to have been exhausted. In a great belt of country, forty miles broad and over three hundred miles long and occupied by Huronian rocks in the Northern section of this Province, the prospects of the discovery of gold are undoubtledly bright. And only within the last year or so extraordinarily rich gold fields have been discovered and are being developed within the extension of this belt in the Province of Ontario. But heretofore the most important Canadian goldfields have been found in the Cordilleran regions of theWest a country generally difficult of access until communication has been afforded by railways. Within the next few years, fields, only small portions of which have been as yet explored by the prospector, but which small portions by early and crude methods of mining have yielded much gold, will be made readily accessible; and on the testimony of geologists it is not unreasonable to expect in consequence a repetition of discoveries such as those of Cariboo and Klondike.

As to silver, the Cobalt area believed at first to be limited to eight square miles is now proved to cover a territory at least double that originaly estimated; while new, if less rich silver mines, are being developed in neighbouring localities. Again, in Northern British Columbia, valuable deposits of argentiferous galena have been found in a region through which the Grand Trunk Pacific Trans-Continental Railway will pass.

The undeveloped copper resources are likewise enormous. In certain localities in Nova Scotia the indications are exceedingly promising. In Quebec, a wide opportunity is afforded for the establishment and development of a considerable copper mining and metallurgical industry in the Eastern Townships; while again, in the Northern district of Chibogomou, most promising discoveries of large copper deposits have been reported.

In the Hudson Bay region in numerous localities copper occurs, while on the testimony of Mr. J. B. Tyrrell[1], »the most interesting, and probably the most extensive copper deposits in Canada are contained in the Keweenawan traps and sandstones which extend along south of the Arctic Coast from Coppermine River eastward to Bathurst Inlet«.

In British Columbia the productive copper mining area is steadily expanding; and in addition to the new Portland Canal region in the extreme north, where the development of deposits of unusual size was recently inaugurated, promising new copperbearing areas have been discovered in the Skeena River valley country. And so this enumeration might be continued, but, perhaps, for present purposes enough has been said to indicate the illimitable potentialities of the mineral industry of the Dominion.

OPPORTUNITIES FOR INVESTMENT.

Until within the last few years a very considerable proportion of the capital invested in the development of Canadian mines originated from the United States, and in a much lesser degree from Great Britain. Recently, however, Canadians themselves have engaged largely in mining undertakings, and there is now no longer difficulty in securing capital locally for the prosecution of any meritorious venture. At the same time foreign capital invested in the development of the mineral resources of the country is both welcomed and encouraged. There can be no doubt that there are many excellent opportunities for such investment at the present time; but a successful issue will necessarily be also dependent on the exercise of ordinary business-like discretion on the part of investors themselves. Such a remark might easily appear to be unsuperfluous were it not explained that fully seventy-five per cent. of the failures of foreign mining companies operating in the Canadian field, are ascribable to faults of judgment or business administration.

[1] Minerals and Ores of Northern Canada, Jour. Can. Mining Institute, Vol. XI, page 357.

Probably the best returns on foreign capital investment may be expected by means of the organization of »development« or »prospecting« syndicates employing thoroughly qualified men, preferably Canadians, to take charge of operations. This plan, it is interesting to note, has already been most successfully adopted by a group of German investors, who have recently devoted effort to securing mineral properties, but more especially coal areas in Canada.

CONCLUSION.

In submitting this paper, the writer is aware of its many short-comings, and would disarm deserved criticism by apologizing in advance. He has merely attempted to present a hasty survey of a wide subject from information largely compiled from various sources, official and otherwise; but in any event believed to be reliable. The result is necessarily fragmentary. It is, however, hoped that such information as is here afforded may serve to stimulate interest and occasion further enquiry concerning the mineral resources of Canada.

3 0112 072836304